SUPPLY CHAIN INNOVATIONS FOR DELIVERING SUSTAINABLE CONSTRUCTION IN UNITED KINGDOM

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Abstract

This research study identifies the key elements, the drivers and barriers which impact on the innovative supply chain practices of the building products suppliers and therefore the sustainability of the UK construction Industry. In particular, sustainability continues to be an important thought for the UK construction industry materials/products suppliers. The study draws upon a number of literature themes such as product development, parameters of innovation, product innovation, rapid prototyping, collaboration, lean production practices, perspectives of supply chain; supply chain management, supply chain innovations, research and development; research and development; sustainability; sustainable construction; and benefits of sustainable construction to the environment. This study supported process of identifying different innovative supply chain practices in the building products manufacturers, a sub-sector contributing to the sustainability of the UK construction industry. Starting with the initial aim of exploring features that impact positively or negatively on innovation of supply chain practices and different theories, a number of frameworks as well as literature and approaches for innovative practices within the construction industry were reviewed. It is understood that the supply chain practices in the construction industry are integrative, interrelated and impacts the sustainability. Therefore it was important to further examine the industry supply chain relationships, the drivers of industry supply chain and impact on organisational performances. The building products manufacturers sub-sector within the UK construction industry is being transformed profoundly due to a number of factors including new products development, new markets, and increased environmental awareness, global reach of organisations and changing customer expectations as well as lifestyle; these companies are expected to consider sustainability and environmental issues while developing innovative supply chain strategies. The specifics include innovative issues around sourcing materials and products; the marketing and lifetime operations of construction industry initiatives; and even disposing construction wastes either from construction activities or at the terminal stage of construction products.

From the relevant literature and contexts study of the UK construction industry, a theoretical framework was informed and questions for the survey were identified. For the questions raised and during the design of theoretical framework a mixed methods research methodology was adopted to collect quantitative data through a questionnaire and a case study. The quantitative data were analysed using SPSS software. Through the results from the data analysis, and interviews with the industry practitioners within the supply chain, a conceptual framework was developed and further adjusted to identify three core influencing groups of factors –company, industrial and regulatory; and further enhanced through the case study interviews. Finally, the interactions between these factors were focused on and the results used to articulate the research findings.

This study confirmed that some of these organisations already had an excellent past experience of supply chain management and were informed of regulations affecting the UK construction industry. There is evidence that some of these organisations were leading in innovation of supply chain practices to enhance their competitiveness and therefore increase industry market share and profitability.

This research proposes a new conceptual framework for the UK construction industry practitioners and makers. It is expected that it will motivate as well as aid the UK construction industry stakeholders to evaluate the existing innovative supply chain practices and therefore influence sustainability.

It is further expected that this study will help the Industry players to better understand the importance of various sustainability drivers and the barriers which prevents adoption of innovative supply chain practices. Additionally, the results from the study will be used as motivators towards adopting innovative supply chain practices in the UK construction industry to improve sustainability.

Keywords: Supply Chain Innovation, Construction industry Supply Chains, Knowledge Management, Sustainability, Conceptual Framework

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Dedication

I dedicate this Study and associated work to my family. To my mother Bhiniben, father Lakhabhai, and my lovely wife Anjana, who is the constant source of strength in my being; and to my daughter Anuja and son Yuvraj, both never, miss the opportunity to motivate me.

Declaration

This Thesis is submitted to De Montfort University, Leicester – UK, in accordance with the University's rules and regulations.

I hereby, declare that this work or any other part has not previously been presented in any form. I have also acknowledged the works of other studies and therefore, all contents of this thesis are as a result of my own effort.

Signature …………………………………………….

Date …………………………………………………

Jiva Lakhabhai Odedra

Approval

This PhD Thesis has been examined, and approved and submitted to the Graduate school office (GSO), De Montfort University, Leicester, England, UK

Signature and Stamp ……………………………………………….

Date ……………………………………………………

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List of abbreviations

BIM - Building Information Modelling

BIS - Department of Business and Innovation Skills

CAD - Computer Aided Design

CIDB - Construction Industry Development Board

CSC - Construction Supply Chain

CSCs - Construction Supply Chains

DV - Dependent Variables

EDI - Electronic Data Interchange

EoS - Economies of Scale

ERP - Enterprise Resource Planning

FA - Framework Agreement

FMS - Flexible Manufacturing Systems

GSCF - Global Supply Chain Forum

GVA - Gross Value Added

JIT - Just in Time

KM - Knowledge Management

LED – Light Emitting Diodes

NPD - New Product Developments

NZEB - Net-Zero Energy Buildings

PDMA - Product Development and Management Association

SC - Supply Chain

SCM - supply chain management

SMEs - Small and Medium Size Enterprise(s)

SPSS - IBM Statistical Package for the Social Sciences

TPS - Toyota Production System

TQM - Total Quality Management

UK - United Kingdom

VFM - Value for Money

Chapter One
Introduction

1.1. Research Background

Leedy and Ormond (2005) had described research as a procedure through which attempt is made to systematically and with the evidence of actual facts, answer questions or solve a problem. Additionally, authors such as Miller (1991) and Patton (1990) had indicated that the purpose of research and in particular, applied research is to contribute new knowledge.

The main objective of this thesis is to offer doctoral research that has been undertaken on the innovative supply chain practices within the UK construction industry and therefore generate new knowledge for its sustainability. It was stated in the past that undertaking a research initiative is a major task which presents the researcher with varying challenges and difficulties including; over-ambition, declining excitement, and need for tedious work over a period (Phillips and Pugh, 1987). However, it is equally conceivable that these challenges are often a result of time mismanagement and a lack of planning.

The general steps taken for this research were reviewing the relevant literature; defining the objectives; articulating the questions as well as hypothesis; specifying the contexts on which research was to be conducted; selecting the research methodology; analysing the data and case study; and drawing conclusions.

The process of preparing a complete, correct and readable presentation of findings is no less demanding; and it was important to seek help when in doubt about how to design, complete and analyse the data.

1.2. Statement of Research Problem

This research explores issues of sustainability within the UK construction industry around innovative supply chain practices and carries out an in-depth analysis of building products manufacturers. That is, it discusses the supply chain innovations and the development of the construction industry in the United Kingdom starting from; wood construction, concrete and cement, steel and currently the adaptation of sustainable construction policies and practices. It is expected that, the research findings will identify the impact of supply chain innovation on the construction industry in the United Kingdom and stress the need for the authorities representing the regulators as well as industry stakeholders to deliberately review and improve on subsisting sustainable construction polices.

By examining existing research findings and knowledge, it is expected that an academic knowledge contribution will be made.

1.3. Research Aims and Objectives

This research is aimed at critically analysing all available supply chain procedures amongst building products manufacturers and understanding how innovations within the UK construction industry sector could possibly drive and or deliver sustainable construction. Basically, effective and efficient supply chain is the nerve centre (Yuva, 2002) of the construction industry, although and arguably, it is viewed that innovative approaches to supply chain could deliver a robust and sustainable construction sector in the UK. Thus, the researcher seeks to explore new and innovative ideas relevant and required for changing existing mechanisms to evolve a much more sustained construction industry in the UK. To achieve this, therefore, a detailed review of existing literatures was carried out which drilled down on theories and principles regarding the role of supply chain in the construction industry. This will help determine where and why innovation is critically needed in the existing supply chain approaches to potentially guarantee an effective and efficient as well as sustainable UK construction industry. Epistemologically, it includes the use of qualitative and quantitative triangular approaches with a mix of positivist and social constructivist approach.

The main aim of this study was to develop a conceptual framework that can be used by policy makers to enhance the understanding and improve role of innovative supply chain processes and/or practices in improving the sustainability of the UK construction industry.

In order to achieve this aim, the following objectives were undertaken:

1. Examine the key elements of innovative processes and/or practices within the UK construction industry supply chain.

2. Review the relevant literature and identify emerging gaps in adopting innovative processes and/or practices in the UK Construction Industry.

3. Identify the key parameters, drivers and barriers in adopting innovative supply chain processes and/or practices within the UK Construction Industry.

4. Establish the extent to which UK industry management practices, organisational performances have contributed to sustainability.

5. Provide best practice framework to guide the construction industry professionals in designing and adopting innovative supply chain in the UK construction industry.

These objectives will be addressed through the lenses of a number of key stakeholders as follows:

- Objectives 1, 3 and 4 – UK construction industry supply chain organisations
- Objectives 2 and 5 – Academics and policy makers

1.4. Research Questions

Research study questions were organised in order to guide and keep the study focused within the literature that was examined.

There were five main research questions to be addressed by this study through the stakeholders.

1. What are the key elements of Innovative practices and/or processes within the UK Construction industry supply chain?
2. What are the key parameters, drivers and barriers in adopting innovative supply chain practices within the UK Construction Industry?
3. What are the predominant management practices and organisational performances that have contributed to the UK Construction Industry in the last 10 years?
4. What are the key bodies of literature and gaps in the innovative practices and/or processes in the UK Construction Industry?

5. What are the best practice models to guide the construction industry professionals in designing and adopting innovative supply chain in the UK construction Industry?

Answers to questions one to three were explored through surveys with UK construction industry supply chain organisations, whilst that for questions four to five were undertaken with academics and policy makers.

1.5. Scope of the Research

The UN Environment Commission in 1987, chaired by Gro Harlem Brundtland, had published its findings in Our Common Future containing the widely accepted definition of sustainable development as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). This definition had brought together what is now known as the three pillars of sustainable development; economic development, social development and ecological development under one societal goal of sustainability.

The factors such as environmental protection and conservation of natural resources are considered to be the major supply chain concerns within the construction industry globally. The media awareness and ability to share visual images internationally, has made the agendas around the construction industry sustainability and supply chain innovation critical discussion agendas; this is further aided by global warming and waste management discussions (National Audit Office, 2007, 2015).

The supply chain management is emerging as an important requirement for the sustainable construction industry globally, let alone the UK (Ochieng, E. et al, 2013; Adetunji, I. et. al, 2008); therefore, it was assumed that that research in the supply chain innovation is timely for this research study.

Until recently, the common supply chain management principles in the UK construction industry had been very traditional with limited information sharing. In the contemporary setting the problems facing construction industry in the UK is that around sustainability

There is evidence that the four countries (England, Scotland and Wales including Northern Ireland) within the United Kingdom uses different approach to address the elements of supply chain innovation and construction industry sustainability (House of Lords, 2011). This point is based on the topography and the complex political structure which operates within the UK and how it affects implementation of the sustainability objectives of the construction industry. The basic research pointed out that these divergent approaches could slow down the rate at which the United Kingdom will achieve sustainable development objectives. Furthermore, it examined the growth and problems in the United Kingdom construction industry particularly touching on the roles wood timber, aggregates and cement including steel construction materials plays in pursuit of sustainable construction. The Discussion further elaborated on the various areas of supply chain innovations currently been applied in the construction supply chain to deliver sustainable construction sector. The research finally drilled down on the innovative supply chain practices of building products manufacturers within the UK construction industry and how it impacts sustainability through environmental, social and economic measures. That is, there is clear lack of knowledge on the building products manufacturer and their supply chain innovation practices within the UK construction industry which provides information on the supply chain innovation (Moore and Ochieng et al., 2013; Uren et al. 2000; Moore and Price et al. 2013; Cotgrave and Riley, 2013; Burline, 1999; Halliwell, 2002; Green Construction Board, 2015 as cited in Wilkinson 2015); Parliament House of Commons, 2010; Dai, 2011; Richardson, 2013).

The key research rationale was therefore drawn from the study of a number of literature themes which had contributed knowledge for subject such as product development, product innovation supply chain management, supply chain innovation and knowledge sharing likely to impact supply chain innovation and sustainability within the construction industry.

- For new product development - PDMA (2003), Blischke and Murthy (2000), Ulrich and Eppinger (2011), Baxter and Gao (2005), Johnson et al (2001); for product innovation - Hsu and Fang (2009), Cooper (1999), Balachandra and Friar (1997), Tucker (2001), OECD (2005), Trott (2005), Ettlie (2006), Bessant and Tidd (2007), Salunke et al. (2011), Goodridge et al. (2012), Keeley et al. (2013), Coad et al.

(2014), Coad et al. (2014), Wheelwright and Clark (1992), Annacchino (2006) Boer and During (2000), Katayama and Bennett (1999), Shah and Ward (2003), Wilson (2010), Enkel et al., 2011).

- For the Lean production practices - Krafcik (1988), Womack et al. (1991), Womack and Jones (2005), Browning (2003), Karlsson and Ahlstrom (1996), Khan et al. (2011), Ward et al (1995), Sobek at al. (1999), Morgan and Liker (2006), Alam et al. (2010), Gunasekaran (2001), Xiaoli and Hong (2004), Wang and Koh (2010), Meybodi (2003), Anderson (2004), Feitzinger and Lee (1997), Nakashima et al. (1995), Imai (1986), Fox (1994), Saini (2015), Blecker and Kaluza (2003) and Gardner (2009).
- For the perspectives of supply chain - Teuteberg and Wittstruck (2010), Farmer (1972), Delfmann and Koster (2005), Cousin, D. P. et al. (2006), Kelvin et al. (2006), Kraljic (1983), Womack et al (1990), Lamming (1993), Rich et al (1997), Trent (2008) and Wisner, 2009.
- For the supply chain management – Stevens (1989), Awasthi and Grzybowska (2014), Cholette and Venkat (2009), Cousin et al (2006), Oliver and Webber (1992), Heikkila (2002), Frazier (1999), Delfmann and Koster (2005), Kelvin et al (2006), Cousin et al. (2006), Storey et al. (2006), Burgess et al. (2006), Pfohl (2000), Delfmann and Koster (2005), Cousin et al. (2006), Pualraj and Chen (2004), Croom et al. (2000), Burgess et al (2006), and Croom et al. (2000).
- For the supply chain innovation – Trent (2008), Fisher (1997), Tan et al. (2011), Shapiro (2009), Christian et al. (2012), Williamson’s (1985), Christian et al (2012), Kanter (1994), Christian et al (2012), Jorde and Teece (1989), Modi (2006), Gerwin and Barrowman (2002), Burt and Soukup (1985), Clark and Fujimoto (1991), Modi (2006), Bonaccorsi and Lipparini (1994), Turnbull et al. (1992), Wasti and Liker (1999), Eisenhardt and Tabrizi (1995), Vickery (2011), Flynn, et al (2011), Barratt and Oliviera (2001).
- For the research and development - Bosworth et al. (1993), Frattini and Cheisa (2009), Bayus (1998), Berger et al. (1998), Rashkin (2007), Williamson et al. (2010), Elkington (1998), Cater and Rogers (2008), Michael Blowfield (2013), Morana

(2013), Carter and Rogers (2008), Smith (2002), Bossel (2000), Tladi (2007), Stands (2000) and Gechev (2005);

- For sustainable construction - Mather and Cornick (1999), Rojas (2008), Ofori (1990), Rusk and Bhattacharjee et al. (2012), Ofori (1993), Christian et al. (2012), Cornick (1996), Christian et al (2012), Barrett (2008), Conte and Monno (2001), Kibert et al (2000), Zachmann (2000), Maiellaro (2001), Tanker and Burt (2004) Hermreck (2012), Kibert et al (2000), Calkins (2009) were considered for research.
- For the benefits of sustainable construction to the environment - Tanker and Burt (2004), Hulse (2007), Halliday (2008), Ofori (1990), Rusk and Bhattacharjee et al. (2012), Asiedu and Scheublin et al. (2007), Kunstler and Salingaro (2001) and Halliday (2008).

In the UK, a research paper by Department of Business, Innovations and Skills (2013), had acknowledged that during the structured interviews, alternative selection criteria that might favour UK suppliers, including security of supply, length of supply chain and sustainability impacts were not mentioned widely; and had further stated that this short coming clearly creates a challenge if the industrial strategy is to play a role in strengthening the competitive position of the UK manufacturing sector. Additionally, while emphasising much more focus on the Environment, the paper had stressed that the construction industry must become a sustainability leader and adopt carbon efficiency into all our processes. Additionally, this paper had noted that that the transfer of the risk includes compliance with planning, regulatory compliance, building performance, sustainability standards and so on; it was pointed out that the effective management and mitigation of risk would reduce waste and cost, and would improve outcomes for the client and for the industry; and contrast, poor risk management practice had the potential to increase costs within the supply chain – affecting margins and reducing efficiency.

It is noteworthy, though that this research had failed to emphasise or even discuss the importance of supply chain innovation and its impact on the sustainability of the UK construction industry.

Furthermore, there have been many definitions of sustainability. Williamson et al. (2010) had commented on definition of sustainability – any development that meets current needs without compromising, endangering or eliminating the ability of future posterity to meet theirs – by World Commission on Environment and Development (1987) and said that this definition is subjective and rather too broad, it does not capture or address the need and mechanism required for individuals and organizations to become more sustainable. Elkington (1998) had provided a more comprehensive concept for organizational sustainability within the context of the triple bottom line covering environment, economics and social goals; and competitive advantages; but even this was considered to be more of an economic relevance of the concept rather than addressing sustainability as the core of the subject matter. Cater and Rogers (2008) had defined sustainability within the context of risk management, transparency, culture as well as business strategy and linking each of these areas with the triple bottom line (environment, social and economic) approach. According to Michael Blowfield (2013) sustainability demands change and total society transformation in contemporary times just as steam age, electricity, printing and IT examples are attributed to radical innovations. However, it was stressed that sustainability has generated complex tension mainly because, if fully applied will cut right through the heart of human social-environmental interactions, by compelling people to make radical changes to their way of life in relation to how it affect the social, environmental and economic performance of their communities, with a view to bequeathing a habitable society to future posterity. This challenge affects what we produce and fundamental nature of prosperity as we currently know it (Blowfield, 2013). Within this context therefore, supply chain management as well as innovation must focus on addressing sustainability by ensuring that sources of raw materials and the supply chain are managed in an environmentally and socially sustainable way with a view to replenish the environment for future posterity. Likewise, Morana (2013) had said that sustainable supply chain management can be viewed as managing information, materials, people and capital flows with the purpose of influencing the economic, environmental and societal life of a given community. Other authors contributing in the theoretical field of sustainability are Smith (2002), Bossel (2000), Tladi (2007), Stands (2000) and Gechev (2005).

Therefore, this research study is determined to inform a conceptual framework which will underpin the nature of supply chain innovation for the building products manufacturers within the UK construction industry and impacting the industry sustainability. While there has been regular talk about improving the manufacturing base of the UK industries (HM Government, 2015), there has been very little evidence of research around innovative supply chain practices of the building products manufacturers in the UK.

More specifically, the introduction of innovation agenda in the supply chain of the UK construction industry to increase sustainability has made the relevant issues even more important. Therefore, it is of critical importance for this research study that the innovative factors impacting the building products manufacturers supply chain practices to make the UK construction industry sustainable are critically examined with a view to create new knowledge.

Furthermore, this research is relevant and resulting conceptual framework would help with recognising the current knowledge gap and therefore, develop better insight into the nature of supply chain innovation for the building products suppliers in the UK construction industry.

One of the indirect objectives of this study is that proposed knowledge can be operationalised by the construction industry in the UK. This research study would therefore be transparent, specific, relevant, interconnected, answerable and measurable.

Overall, this research study would enable drawing of meaningful conclusions and recommendations from data being collected to meet research objectives. It is expected that the findings from this study would offer additional empirical data for the policy makers to possibly guide them on putting forward industrial and regulatory guidance towards sustainability of the UK construction industry. Furthermore, the industry practitioners would benefit from the research data and findings to improve the internal processes and ultimately become more efficient and effective participants in the UK construction industry supply chain.

In short, this research study provides new insights into the UK construction industry by examining it from a different angle. It is expected that this research study would be of interest to those concerned with the theory and the practice of innovation practices in the supply chain. Finally, it is expected that this research study would provide a clear link. The proposed research process is summarised in the Figure 1.1.

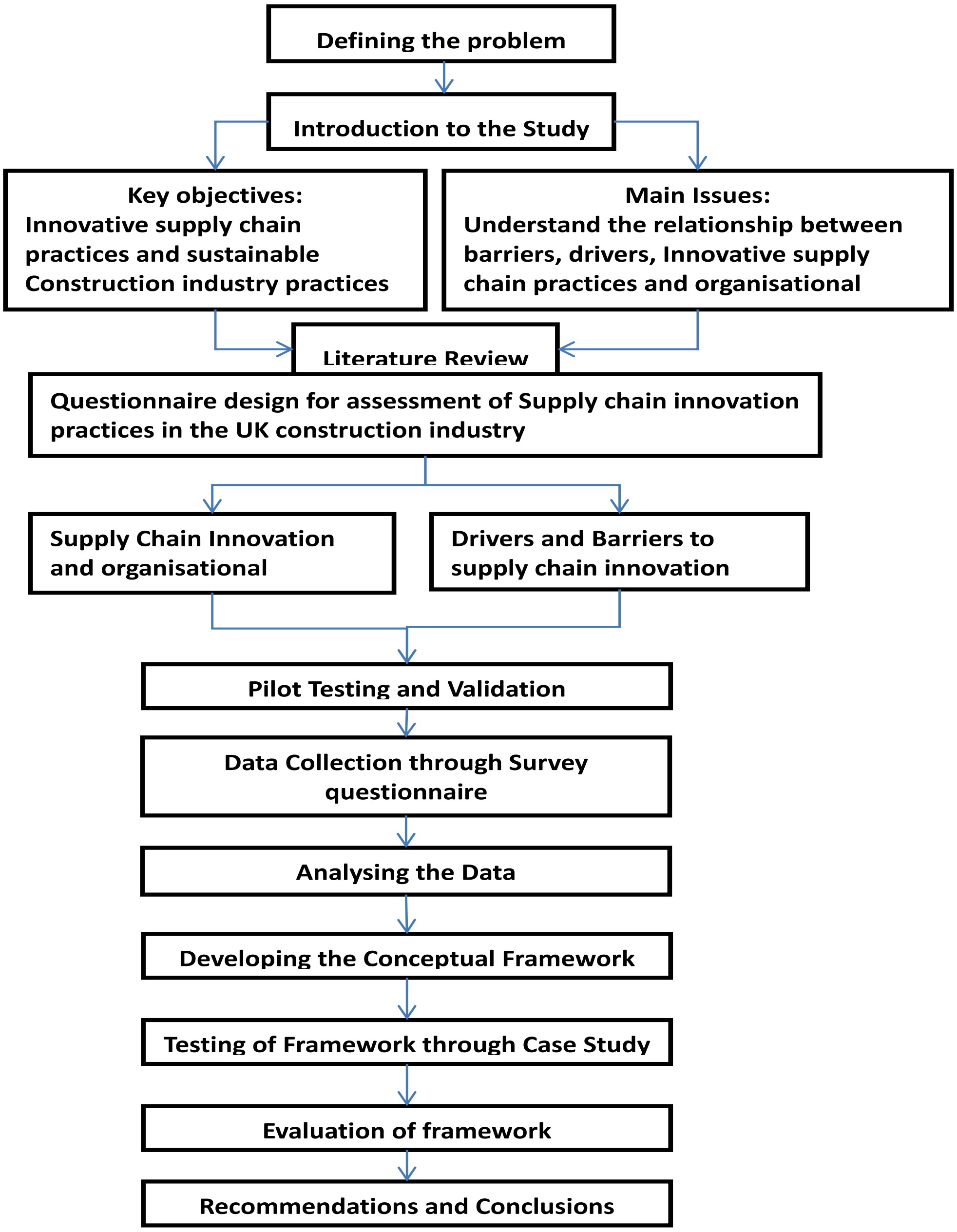


Figure 1.1 Summary of research process for thesis

1.6. Research Methodology

For this study, a mixed method approach was adopted via the choice of a survey questionnaire (quantitative) and expert interviews (qualitative) to collect data to validate the findings from the literature and the conceptual framework. Therefore, this mixed methods strategy was divided into eight stages:

- Stage 1: Determine Whether a Mixed Research is appropriate
- Stage 2: Determine the Rationale for mixed methods
- Stage 3: Select a mixed method or mixed model design Research
- Stage 4: Collect the Data
- Stage 5: Analyse the Data
- Stage 6: Validate the Data
- Stage 7: Interpret the Data
- Stage 8: Write the Research Report

The study further established the target population, the recruitment of respondents based on the external data (BIS, ONS) and the literature analysis. Moreover, quantitative data is analysed in SPSS. Based on the nature of the data (Ordinal Scale, Non-parametric) data analysis tools were employed (see chapter 4). These were Cronbach's Alpha (reliability analysis), Frequency analysis (descriptive) and the Kruskal-Wallis H test (Non-parametric). This helped to test the hypothesis for each variable via boxplot summary and asymptotic significance and Spearman's Correlation (Correlate) analysis to identify the correlation significance among the variables. However, employing these tools was not sufficient for this study because of testing the findings from different disciplines. In that situation, interpretive correlation rank-order analysis was employed to draw the assumptions and generalise the results for further study. The conceptual framework was modified through the findings. Those findings were further analysed and validated through the qualitative data. To validate the findings from the literature review this study sought the help of employed experts from a construction background for semi-structured interviews. The data collected was analysed through interpretive analysis and the results were generalised to take steps towards finalising the framework. The case study helped to gain better and practical understanding of the building products suppliers including the barriers and drivers. Therefore, the data analysis and the case study enabled development of the conceptual framework. Finally, the framework was further explored and the conclusions as well as recommendations were made for the interactions between the company and the industry factors; the interactions between company and regulatory factors; the interactions between industry and regulatory factors; and the interactions between the company, industry and regulatory factors.

The data were analysed using SPSS. The research methodology approach consisted of five stages:

A – The questionnaire design and testing; B - Sample selection; C – Data collection and sample characteristics; D – Data Aanlysis; and E – Case study and evaluation of innovation in supply chain and contribution to construction industry sustaianability.

The criteria's listed in the literature review were used to develop the questionnaire for the survey (Appendix A). The questionnaire was directed at the building products manufacturing companies and targeted the different management groups within the organisations, product managers, project managers, purchase managers, supply chain managers and organisational owners or directors.

Overall, 61 respondents completed surveys received and each survey had included 179 questions. For the responses received different statistical analysis were carried out.

The different types of data collection strategies, data analysis tools and techniques had been analysed; the assumptions that led this study to define the potential population for this study; and the factors that hinder obtaining a large response rate were discussed. The questions resulting from the literature review and its variables were used to establish hypothesis list for variables so that it can be tested in SPSS. That is, hypothesis testing for establishing relationships between innovative supply chain drivers and sustainable construction practices; and subsequently the impact of the innovative supply chain practices on the organisational performance.

With aid of construction industry experts, a conceptual framework was developed to gain better insight in to nature of innovation in the supply chain practices of building products manufacturers within the UK construction industry. The framework was tested through a case study. Based on the analysis, conclusions were drawn for the framework and its application.

1.7. Research Challenges

The challenge of identifying and assessing relevant practicing design professionals within the building products suppliers for the UK construction industry who were prepared to provide response to comprehensive as well as exhaustive survey questionnaires and interviews needed to be addressed. A further complication was the fact that the researcher has not been working as a professional in the UK construction industry. Consequently, there was a concerted effort to gain meaningful engagement with the building products suppliers in the UK construction industry. The process of engagement took a rather long time, as it required developing rapport, earning the trust and gaining respect or credibility of the stakeholders. For this, it was important to participate in relevant conferences; local, regional and national exhibitions; establish relationships with different trade bodies; and access relevant UK construction industry journals and publications. Additionally, this allowed overcoming these limitations by carrying out comprehensive literature reviews on theoretical materials relevant to the research area, consulting publications as well as on-line library sources. This has helped to broaden the secondary data sources which were necessary for underpinning academic contribution of this research.

1.8. Structure of the Thesis

The structure of the thesis is outlined as follows:

Chapter 1: Introduction – Research background

This chapter presented the research background and stated the main aims and objectives of the research study. In the main, this chapter provides a snapshot view of the entire research study and each section adding information steering towards research structure. The chapter summed up the research contribution and knowledge contribution for supply chain innovation for the UK construction industry.

Chapter 2: The Literature Review

This chapter has reviewed some literatures (articles in Journals, books, professional Journal articles, government reports and UN and other international agencies reports) on the ten key sub-themes that drive this research thesis.

Chapter 3: Context of the Research

This chapter discussed the various approaches that United Kingdom uses to approach the issues of sustainable construction and construction supply chains issues generally. The chapter considered different reports and studies to explore the negative impact of fragmentation in the construction sector and its sub-causes.

Chapter 4: Research Methodology

This chapter has presented the research methodology adopted for this research project. Philosophical assumptions were explained, and reasons given as to why this research rest towards a pragmatic stance. The case is made for the adoption of a mixed-methods approach and the rationale behind the selection.

Chapter 5: Data Analysis

This chapter summarises the data analysis to discuss and inform the key themes of the conceptual framework. The responses from the survey were grouped according to Likert scale and analysed using Statistical Package for the Social Sciences (SPSS, version 22.0).

Chapter 6: Industry Case Study

For the case study, the framework elements which were developed for supply chain innovation practices in the organisation were tested.

Chapter 7: Conclusions and Recommendations

This chapter summarises the research findings and therefore brings together the literature review, the methodology used for the research, the data verification, the case study and the formation of a new conceptual framework.

A summary of the structure is provided in Figure 1.2 below.

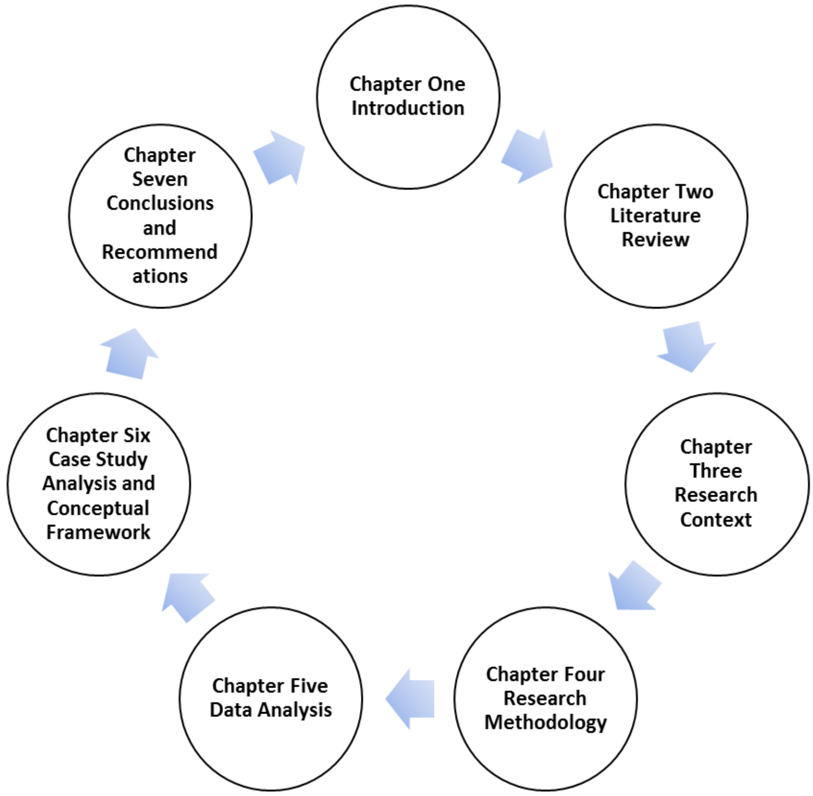


Figure 1.2 A diagrammatic structure of thesis

Chapter Two

Literature Review

2.1. Introduction

This chapter presents the concepts of supply chain, innovation and sustainability. That is, the chapter includes different definitions of supply chain innovation, review of different frameworks and approaches to supply chain; the recognition of different drivers and barriers to supply chain innovation, innovation practices and sustainability.

In order to understand the concept of supply chain innovation, it is of critical importance to understand different theoretical themes around supply chain innovation and sustainability.

Therefore, the literature review is divided into sub-themes or sections representing product development, parameters of innovation, product innovation, rapid prototyping, collaboration, lean production practices, perspectives of supply chain; supply chain management, supply chain innovations, research and development; research and development; sustainability; sustainable construction; and benefits of sustainable construction to the environment. This is necessary to engage in a more focused discussion, review relevant literatures and most importantly draw on key critical arguments as they may concern each concept that embodies the research question without any form of ambiguity.

In order to bring the discussion into a pragmatic academic focus, a historical snapshot to the evolution of supply chain will be undertaken. This is followed by review and analysis of arguments advanced by different commentators on the concept of supply chain management. Furthermore, literatures on supply chain innovations which is, critical to the research, will be examined and the role played by research and development will also be discussed. The various debates on the concept of sustainability will equally be discussed followed by the review of literatures on sustainable construction, which is another key aspect of the research. Finally, various arguments about the benefits of sustainable construction to the environment will be explored, and after this, the research would have been given a constructively tight academic underpinning necessary to focus it on supply chain innovations and delivery of sustainable construction sector.

2.2. Successful Knowledge Sharing

For the UK construction industry supply chain there are likely to be many partnerships in a typical project and therefore it is important to examine the theory about knowledge sharing. It was Davenport and Prusak (1998), who had identified four mechanisms for the sharing of individual knowledge within organisations:

- Contributing knowledge to organisational database,
- Sharing knowledge in formal interactions within or across teams or work units,
- Sharing knowledge in informal interactions,
- Sharing knowledge within practice communities.

Additionally, Kim and Nelson (2000) had stated that knowledge sharing also occurs as a dynamic learning process involving organisational interactions with customers and supplier, resulting in innovation or creative imitation; and due to advancement in information this process frequently involves differentiated knowledge that is shared between organisational functions and external customers as well as suppliers. This thought was also echoed by Epple et al (1999) in a discussion around level of emphasis on the importance of knowledge sharing for organisational performance and effectiveness in the private as well as the public sectors. That is, the knowledge sharing activities create opportunities for organisations to maximise an ability to meet changing customer demands or needs; and therefore, to product solutions for competitive advantage.

It is noted that Yeung et al (1999) had suggested that sources of knowledge is also an important factor affecting the success of knowledge transfer. That is, a skilled source is able to manage knowledge sharing activities in such a way that it improves an industry learning of the specific knowledge.

Towards successful knowledge sharing it was Nonaka, et al (2000) who had concluded that a successful knowledge sharing effort requires a focus on more than simply the transfer of the specific knowledge between functions within an organisation internally as well as externally. That is, the activities to be performed need to focus on structuring and implementing the arrangement in a way that connects both existing and potential relationship issues; and examining the form and location of the knowledge to ensure its complete transfer.

In the main, while the means and levels for sharing knowledge, which could include documents or files, professional presentations, work task schedules are critical in overcoming the causes that could obstruct, change the context, complicate or harm knowledge and has a critical role in ultimately determining the results of a knowledge sharing effort in industries such as construction industry. Therefore, the evaluations of knowledge sharing efforts are required to incorporate assessments of its use of activities related to understanding the form and entrenching of the knowledge, establishing and managing appropriate management structures and aiding the transfer of the knowledge.

Additionally, Argote and Ingram (2000) had also stated that one approach to defining knowledge sharing success centres on the degree to which the knowledge is recreated in industries. The knowledge can be viewed as knowledge packages embedded in different organisational functions of a typical organisation via the people, skills, technical tools, routines and systems used by the organisation; and in the collaboration networks created internally or externally in organisations (Argote and Ingram, 2000 and Barton, 1992).

In fact, Nonaka (2001) had further noted that the diversity of knowledge used by different organisational function is detrimental to knowledge sharing; since each function may have different vocabularies, targets and ways of addressing problems that can sometimes make it difficult to achieve a shared understanding.

2.3. Product Development

New Product Developments (NPD) is a critical process in developing and maintaining a strong position in a competitive business environment. Decreased product lifecycle and increased global competition has given a high level of importance to NPD. Long-term organisational performance is dependent on NPD, continuous changes in customer needs, new scientific and technological discoveries, shortened lifecycles, international and local competitions has forced organisations to either modify existing products or introduce new ones. Failure to address these changes results in organisations losing a vital proportion of competitive advantage (Vayvay and Cobanoglu 2006).

The handbook of product development published by the Product Development and Management Association (PDMA) provides precise as well as succinct definitions of a new product and the associated product development process:

> *A product is a system comprising several elements, which can be broken down into a hierarchy of levels.*

PDMA (2003) had defined the new product development (NPD) as the overall process of strategy, organisation, concept generation, product and marketing plan creation and evaluation, and commercialisation of a new product; new product development process defined as a disciplined and defined set of tasks and steps that describe the normal means by which a company repetitively converts emergent ideas into viable products or services.

It was Blischke and Murthy (2000) who had categorised product into seven levels of hierarchy with system at the highest level and part at the lowest level (Highest level -- system, sub-system, major assembly, Assembly, Sub-assembly, components, parts - Lowest level).

For the contemporary manufacturing initiatives, the products are developed as autonomous projects. According to Ulrich and Eppinger (2011) a product management core team consisting of team leader, manufacturing engineer, mechanical designer, electronics designer, industrial designer, marketing professional and purchasing specialist; and additionally they point out that the core team identify all the concepts of the product and extended team. The extended team at the same time includes suppliers to support the core team with the relevant knowledge and materials. The same authors, Ulrich and Eppinger (2011), had also defined a generic new product development process, which includes six phases:

- Phase 0 is planning - to identify market objectives and assess the current technologies. The output of this stage is a strategic statement including business goals, missions, key assumptions and constraints.
- Phase 1 is concept development – it is most important stages in the process; here product concepts are identified, tested and evaluated in this phase based on customer needs.
- Phase 2 is system-level design – it contains the definition of product architecture and breakdown of the product into subsystems and individual components.
- Phase 3 is the detail design phase – it includes the complete product specifications, such as geometry, tolerances and materials; additionally constraints of the product in adoption are identified to control the risks and failures in actual installation.
- Phase 4 is product test - a prototype of the planned product is produced under the constraints and controls.
- Phase 5 is the production ramp-up - during this phase, the product is to be launched.

This generic product development process is commonly accepted by many different industrial groups responsible for the product developments; it is to be noted that there are variations in different manufacturing companies, including the collaborating company of this project and ultimately depends on the industry.

However, it is also important to acknowledge that the generic process provides a sequential process rather than an iterative process showing feedback or changes.

Understanding customer-supplier requirements is the starting point in project management. This Customer-supplier requirement is expected to be transferred to product design and engineering requirements. Towards this, Baxter and Gao (2005) had proposed a methodology to transfer customer requirements to design and engineering requirements. Johnson et al (2001) had developed a methodology to integrate customer requirements with requirements of other organisations internal as well as external stakeholders.

As a general observation it is noted that there is a familiar problem with project based product development; in that each product development project is carried out independently; and therefore the collaboration between projects is limited. This may lead to the continuous product development between functions within an organisation becoming separated individual projects. This situation could ultimately lead to high cost and time wasted in the development of similar products.

Having learnt that the product development process is chronological with different phases of identifying opportunities, generating short list, selection of ideas, developing prototypes and launching to wider markets; the innovation parameters will be further examined in the literature. These different stages of product developments involves levels of innovation either in product features, processes of development or targeting different markets. It was Hsu and Fang (2009) who had stated that innovative product development is a knowledge-intensive process that requires sophisticated knowledge management skills.

2.4. Parameters of Innovation

It can be claimed that the phrase *innovation* is regularly used by policymakers, product managers, service marketing specialists, advertising specialist and management consultants and not as a strict scientific concept but as metaphor, political promise, slogan or a buzzword (Kotsemir, M N. and Abroskin, A. S., 2013). For example, 'blue ocean innovation' (Kim and Mauborgne, 2005); 'frugal innovation', (Tiwari and Herstatt, 2011); 'organic innovation', (Moore, 2005); 'customer anthropologist', (General Electric and Stone Yamashita Partners, 2005); 'roadblock remover', 'innovation faces', 'cross-pollinator' and 'caregiver' (Kelley and Littman, 2005). Kotsemir and Abroskin (2013), presented a fairly comprehensive list of development of innovation concepts and models in its historical developments including the one presented in Figure 2.1 from year 2000 and onwards.

2000-s
• further development of financial innovation concept [Friedman, 2000; Goodhart, 2000; Woodfor, 2000; Tufano, 2003; Alvarez and Lippi, 2009] • further development of the eco-innovation concept [Jones and Harrison, 2000; Rennings, 2000; Jones et al. 2001; Nuij, 2001; Smith, 2001; Rai and Allada, 2005; Beveridge and Guy, 2005; Pujari, 2006; Carrillo-Hermosilla del Río and Könnölä, 2009]; • further development of the lead user concept in the framework of user innovation concept [Luthje, 2000; Lilien, et al. 2002; Intrachooto, 2004; Luthje and Herstatt, 2004; Skiba and Herstatt, 2009; Skiba, 2010, Oliveira and Von Hippel, 2011] • national systems of innovation mode (in theoretical as well as empirical direction) further development [Chudnovsky Niosi and Bercovich, 2000; Etzkowitz and Leydesdorff, 2000; Nasierowski and Arcelus, 2000, 2003; Nelson, 2000; Edquist, 2001, 2004; Lundvall, 2002, 2007; Lundvall et al., 2002, Niosi, 2002; Monttobio, 2008, Pan, Hung, Lu, 2010]; • theories of growth of regional clusters of innovation and high technology [Keeble & Wilkinson, 2000]; • emergence of the toolkits for user innovation concept in the framework of user innovation concept [von Hippel, 2001; von Hippel and Katz, 2002]; • further development of methodology for the international and national R&D statistics and STI policy measurement [Gokhberg, Gaslikova and Sokolov, 2000; Boekholt et al., 2001; ESCWA, 2003; Katz, 2006; Tijssen and Hollanders, 2006; Gokhberg L. and Boegh-Nielsen, 2007; OECD, 2007; Gokhberg, Kuznetsova and Roud, 2012] • establishment of the theory of social innovation in academic literature [Mumford, 2002; Moulaert and Sekia, 2003; Westley, Zimmerman and Patton M. 2006; Kohli and Mulgan 2007; Mulgan Ali and Tucker 2007; Nichols, 2007; James, Deiglmeier and Dale, 2008; Nambisan, 2008, 2009; MacCallum, Moulaert, Hillier and Vicari, 2009; Goldsmith, 2010; Howaldt and Schwarz 2010; Murray, Caulier- Grice and Mulgan, 2010; Gill, 2012] • further development of innovation intermediary concept [Wolpert, 2002; Stewart and Hyysalo, 2008; Sieg, Wallin and von Krogh, 2010] • further development of technological innovation system concept [Bergek, 2002; Smits, 2002; Hekkert et al., 2007; Negro, 2007; Bergeck et al, 2008; Suurs, 2009]; • further development of open innovation concept [Chesbrough 2003; Vemuri and Bertone, 2004; Zhao and Deek, 2004; Chesbrough, Vanhaverbeke and West, 2008; von Hippel, 2011; Penin, Hussler and Burger-Helmchen, 2011; Pearce, 2012]; • emergence of the collaborative innovation network concept in the framework of open innovation concept [Gloor, 2005; Gloor and Cooper, 2007; Silvestre and Dalcol, 2009]; • further development of user innovation concept [von Hippel, 2005; Braun, 2007; Bilgram, Brem, Voigt, 2008; Nambisan and Nambisan, 2008; Bogers, Afuah, Bastian, 2010]; **(*Note: milestones in development of innovation studies were identified on the basis of analysis of Rothwell (1994), Marinova and Phillimore (2003) and Godin (2008) papers, as well as on the basis of material of Web of Science, Scopus and Google Scholar databases*)**

Figure 2.1 Development of innovation concepts and models in its historical developments, continuation since 2000 onwards

For now, it is suffice to say that there are many definitions of innovation and the parameters have changed over the years significantly; that is, the innovation is no longer seen as product or service breakthroughs, whether radical or incremental changes, especially in the UK manufacturing sector. However, it must be noted that NESTA highlights the importance of – hidden innovation – in order to compete and not remain prisoner to existing technologies and business models (NESTA, 2008b). NESTA had called this Total Innovation; since it includes new organisational structures and business models using existing technologies and beyond.

It is to be noted that some researcher promoting innovation prefer to maintain separation between the business model and innovation (Teece, 2010). Tidd et al. (2005) had separated the types of innovation into product, process, position and paradigm innovations.

Keeley et al. (2013) divided this further into ten types of innovation:

- Profit model,
- Network,
- Structure,
- Process,
- Product performance,
- Product system,
- Service,
- Channel,
- Brand and customer
- Engagement

Additionally, Boer and During (2000) had described manufacturing perspective of innovation where the separation lies in organisational innovation and it concentrates much more on a company's Total Quality Management (TQM).

In fact, to understand the different areas of innovation could include:

- Technological innovation, which focuses on the development of new or improved technologies.
- Product/service innovation, which develops and produces products/services for the market.
- Process innovation, which aims to improve the product/service development processes e.g. NPD and production processes and product delivery processes e.g. logistics and sales processes.
- Organisational innovation, which improves organisational-level management creating company vision and values, strategies and business models to enable a company to embrace innovation culture and succeed in the market.

These areas are closely linked, one area often requiring another area to practise innovation effectively (Bessant and Tidd, 2007) e.g. for successful development and delivery of a product (product innovation), appropriate technology needs to be available (technology innovation) with processes which encourage creativity and maximise efficiency (process innovation) and the sales channels which initiate and maintain sales (organisational innovation). Each area of innovation will be discussed further in later sections.

2.5. Product Innovation

Academics who study product innovation have identified numerous key elements for success. In the main, these key elements represent the most appropriate process for identifying good product concepts and shepherding them through the product innovation process. The organisations and the management which ignore them run a higher risk of failure than those who adopt these elements in the organisational practices.

Cooper (1999) had reported possibly the most succinct set of factors. Coopers conceptualization features seven elements that he calls seven actionable critical success factors that apply to product innovation. The seven actionable critical success factors are:

- Solid up-front homework – to define the product and justify the product.

- Voice of the customer – a slave-like dedication to the market and customer inputs throughout the project.
- Product advantage – differentiated, unique benefits, superior value for the customer.
- Sharp, stable and early product definition – before development begins.
- A well-planned, adequately-resourced and proficiently-executed launch.
- Tough go/kill decision points or gates – funnels not tunnels.
- Accountable, dedicated, supported cross-functional teams with strong leaders.

Cooper also recognizes critical factors in the other process: product management. Key to that list is the information management and its appropriate use. It is practical to assume that larger product development groups would codify the innovation factors into objectives and use them as benchmarks. There is an option for an organization to skip some factors but doing so increases risk. However, it is worth noting that the information control, the critical area for product management, usually requires a significant investment in infrastructure that smaller companies may not be able to afford.

Usually product/service is an outcome of the innovation processes conducted by an organisation. The objective of product/service innovation is to deliver changes in products/services to the customers, to generate profit and therefore improve competitiveness (Balachandra and Friar, 1997, Tucker, 2001, OECD, 2005, Trott, 2005, Ettlie, 2006, Bessant and Tidd, 2007, Salunke et al., 2011, Goodridge et al., 2012, Keeley et al., 2013, Coad et al., 2014).

Since most cases the outcome of product/service, innovation for manufacturers can be unambiguous, resulting in increased sales (turnover) and profitability. Therefore, the product innovation is an important area for measuring an organisation's innovation capabilities (Coad et al., 2014). In order to achieve higher growth through extra sales and therefore more profits, the product/service innovation provides differentiation (Bessant and Tidd, 2007) and improves competitiveness. The main drivers to note are (Wheelwright and Clark, 1992):

- Intense international competition i.e. through globalisation,
- Fragmented, demanding markets - increasingly sophisticated and demanding customer expectation, and
- Diverse and rapidly changing technologies - rapid growth of the breadth and depth of technological and scientific knowledge.

Different product development programmes can lead to product innovation, with different advantages for companies include (Annacchino, 2006):

- New to the world–creating a new market,
- New product line–new entry to an existing market,
- Add to existing products–expanding the product line(range),
- Improve or revise–improving the current product line,
- Repositioning–changing consumer perception of the products, and
- Cost reduction –increasing unit volume or staying price competitive.

The majority research considers the product and service innovation together as one area of innovation. This is because the research identified the importance of product and service innovation to increase manufacturing companies' competitiveness and how they should be closely linked, to maximise the company's innovation capabilities.

Furthermore, manufacturing companies can use flexible manufacturing systems (FMS) to increase quality and reduce costs while also reducing the lead time to deliver products to the customers(Boer and During, 2000). It is closely linked with the lean (agile) manufacturing process which involves minimising waste in defects, inventory, processing (resources in space, energy and people for production), waiting (idle time in production), motion (reduction of unnecessary movement in production), transportation and over-production, to optimise the manufacturing process(Katayama and Bennett, 1999, Shah and Ward, 2003, Wilson, 2010).

The open innovation principle, which is closely linked with collaboration (through strategic alliances and integration of consumers in product development), is also part of process innovation in this research, since it enables companies to develop new innovation processes (Enkel et al., 2011). Process innovation thus requires a strategic balance between business goals and process improvements in production, product developments, and the innovation process itself.

The research identified the close relationship between organisational innovation and strategic management of a business, with top-level managers' decision-making in order to successfully practice organisational innovation to enhance competitiveness.

2.6. Rapid Prototyping

The need for product innovation has never been greater. Product life cycles are becoming shorter and therefore, any new product replaces older versions more rapidly (Harmancioglu 2007).

It is to be noted that the new product development is considered to be one of the riskiest and yet very important activities amongst manufacturers and is therefore, essential for the continued success of the organisation.

However, in the early stages of prototyping, it is difficult to follow the rapidly-changing customer demands; this is also in addition to improving the features for the performance and capabilities of the new product as well as innovative services for maintaining competitive advantage.

In short, Rapid prototyping is a product development process using manufacturing technologies that involves a group of manufacturing techniques that is based on layer by layer material deposition rather than on material removal or deformation (Masood, 2005). Most importantly, rapid prototyping can reduce costs and lead times, which are necessary to bring new products to the market quicker for rapid launch.

Lee and Weiss (1997) had stated that at least six different rapid prototyping techniques which are commercially available, each with unique strengths. Since rapid prototyping technologies are being increasingly used in non-prototyping applications also, the techniques are often collectively referred to as solid free form fabrication and computer automated manufacturing, or layered manufacturing.

Additionally, the rapid prototyping additive nature allows the creation of objects with complicated internal features that cannot be manufactured by other means.

Using specialised software, a 3D CAD model is cut into very thin layers or cross-sections. Then, depending on the specific method used, the Rapid Prototyping machine constructs the part layer by layer until a solid replica of the CAD model is generated. Material selection is also method specific. Wohler (2002) stated that although several rapid prototyping techniques exist all involve a five-step process:

- Creation on of a CAD model of the design
- Conversion of the CAD model into STL format
- Slicing the STL file into thin cross-sectional layers
- Construction of the model layer by layer
- Cleaning and finishing the model

2.7. Collaboration

Collaboration is a structured repetitive process where two or more partners work together toward a common objective. Often, it is an intellectual effort that is creative in nature by sharing knowledge, learning and building consensus. It is to be noted that the collaboration does not require leadership and can even bring better results through decentralisation and egalitarianism.

Additionally, teams that work collaboratively can obtain greater resources, recognition and reward when competing for the limited resources.

In the main, the coordinated methods of collaboration encourage self-analysis of behaviour and communication; and these methods specifically aim to increase the success of partnerships as they proactively engage in collaborative problem solving.

Furthermore, the collaborative planning covers many planning areas. The background idea is to directly connect planning processes that are local to their planning domain in order to exchange the relevant data between the planning domains to improve the local plans (Fleischmann et al, 2002) and the collaboration in the planning process occurs internally and within the supply chain. Manufacturing companies, which develop new production planners, collaborate with staff and sales planners about capacities, workloads and demand. Within some organisations, a final form of consistent goal orientation exists, whereas in a collaborative planning situation, spanning multiple different organisations, such common focus is often absent.

For collaborative practices many authors stress the necessity of common goals, clear performance metrics, and a culture that encourages collaboration. Fleischmann et al (2002) had stated that collaborative planning requires a collaborative relationship with the intent of establishing a mid-term relationship to enable planning activities and the exchange of expertise based on partner information to create additional value. Barratt (2004a) had lists a number of critical aspects for collaboration in a supply chain, dividing them in three groups: cultural and strategic elements and aspects of the collaboration itself. A collaborative culture of external and internal trust must exist, mutuality, information exchange, openness and communication. Mutuality is the sharing of profits and risks of collaborative work. Strategic elements include resources, commitment, and a corporate focus on the collaboration, intra-organisational support and supporting technology. Finally, regarding the collaboration itself the management of change is emphasised; that is, collaboration means flexibility, alignment of activities and processes, joint decision-making and the sharing of performance metrics. Moyaux (2007) had used one definition for collaborative planning, forecasting and replenishment and collaborative relationships: collaboration where two or more parties in the supply chain jointly plan a number of promotional activities and work out coordinated forecasts; and this serves to determine the production and replenishment processes. The distinction between the different forms lies in the scope and depth that are normally defined in a number of dimensions:

- Amount of shared information (only sales orders, or also production and promotion data)
- Degree of discussion (from no discussion to frequently discussion)
- Goal of the collaboration (cost reduction, improved client service or joint product development)
- Level of coordination and synchronization
- Presence of evaluation, feedback and competence management

This results in three collaborative planning, forecasting and replenishment forms varying from low to high scope and depth of collaboration: basic, developed and advanced collaborative planning, forecasting; and replenishment with three types of relationship: transactional, information sharing and mutual learning. Additionally, different theoretical perspectives like the transaction cost economics (little collaboration, a few common goals, partners in collaboration focused on own profits) and a strategic relationship management or network approach (coordination of all almost all business processes, common goals, focus on collaborative performance) are advised to be used to better understand collaborative planning (Moyaux, 2007).

2.8. Lean Practices

In 1988, Krafcik, a quality engineer for Toyota initially introduced the term 'lean' as opposed to 'buffered' in a magazine article to describe the Toyota Production System (TPS) as compared to the mass production system.

Additionally, in *The Machine that Changed the World* at the beginning of 1990s, Womack, Jones and Ross introduced the concept of 'lean manufacturing' to the western world based on TPS. According to Womack et al. (1991) lean was described as a management method that was not strictly assigned to the manufacture of automobiles but could be applied to other industries. All though *The Machine that Changed the World* was not an academic publication, it is acknowledged as an important publication in the research on lean.

Womack, Jones and Ross generally define lean as "tools and methods through which waste is minimised while end user value is maximised and continuous improvement can be achieved." Similarly, Womack and Jones (2005) introduced five principles, the first stage being *specify value*. Without knowing what a customer values, it is considered impossible to deliver a product that truly satisfies a market. Compounded with this jump to eliminate waste without first understanding value, is the perception that the lean thinking principles do not translate to the product development process (Browning 2003). The remaining principles include: identify and map the value stream, create flow by eliminating waste, respond to customer pull and pursue perfection.

Additionally, Karlsson and Ahlstrom (1996) also carried out research based on observing several industries to come up with recommendations about the path to Lean Product Development. The research did not define the meaning of lean and the general recommendations were more related to Concurrent Engineering applications such as supplier involvement, cross-functional teams, simultaneous engineering and integration of activities.

There were two major lean thinking projects in USA and UK. The Lean Aerospace Initiative coordinated by MIT (USA-LAI 2010) and the UK Lean Aerospace Initiative (UK-LAI 2007). The project was specifically oriented to the aerospace industry in USA and UK and the information was withheld from the public domain. The second project was IMVP, the efforts started by understanding the TPS through publishing the book *The Machine that Changed the World*. Most of the efforts were put in understanding lean applications on the shop floor and developing both practical models and lean techniques to help implementation. This effort further evolved to the lean transformation of the enterprise. This is now called the Lean Enterprise that covers the adoption of lean thinking to the management of the enterprise as well as it supply chain (Khan et al. , 2011).

Lean product and process development can be described as an incremental progression in the journey of lean thinking. Ward et al (1995) have attempted to describe the Toyota Product Development (PD) from a design perspective; Sobek at al. (1999) proposed the set-based concurrent engineering alongside its principles and tools, Morgan and Liker (2006) presented 13 principles of lean product development which have been categorised under three distinctive groups i.e. people, processes and technology, Figure 2.2.

Additionally, as highlighted in Figure 2.2 the application of lean thinking in PD is not firmly established as lean manufacturing and lean enterprise, it is considered a new idea; there are no tools, no value stream mapping, and no practical models. Whilst much work has been published concerning the implementation of the lean principles into product development, little evidence has been presented to validate its success (Alam et al. 2010).

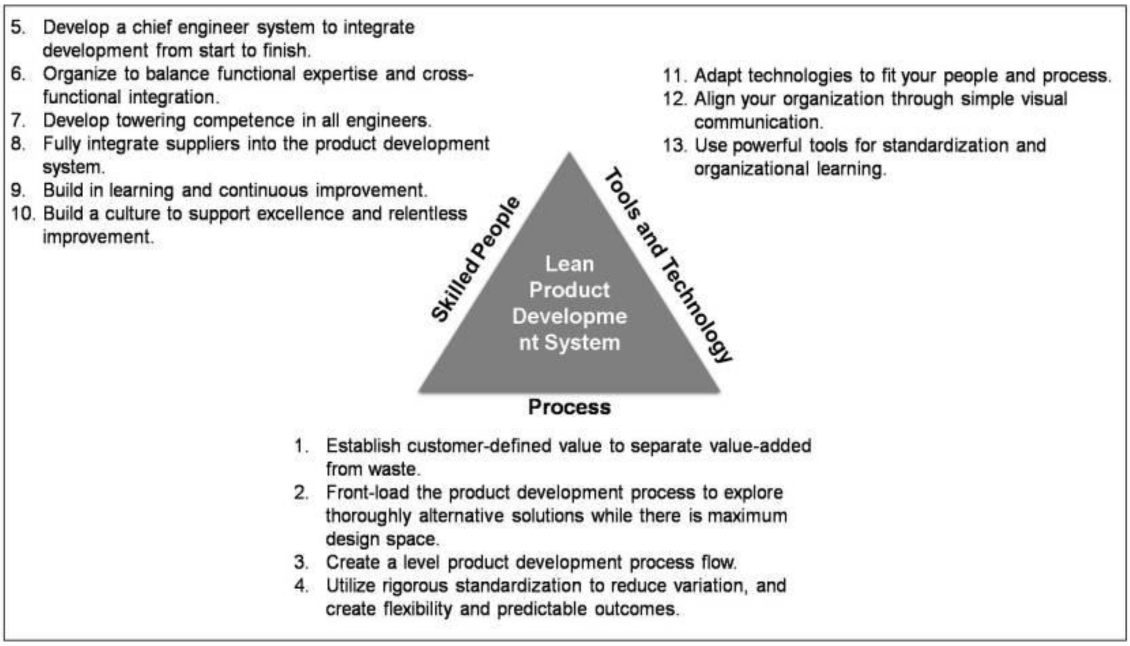


Figure 2.2 Morgan and Liker (2006) presented 13 principles of lean product development

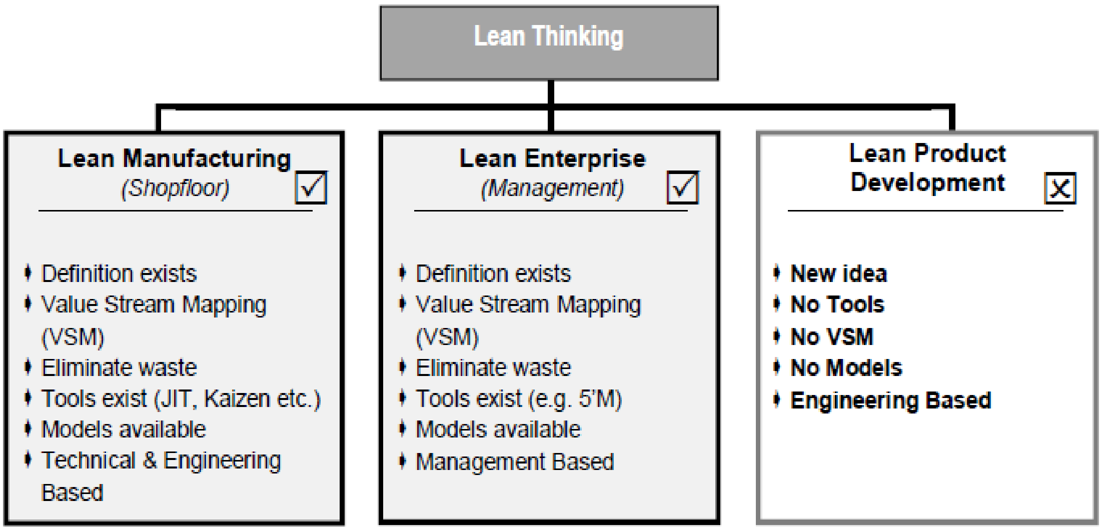


Figure 2.3 Application of lean thinking

The Toyota Product Development places emphasis on process engineering and process simplification. This is achieved not through the extensive use of control charts, rather inbuilt techniques such as Poka-Yoke, Single Minute Exchange of Dies (SMED), and Quick Change Over, Andonds etc. (Bicheno and Mattias 2009) as shown in Figure 2.3. An inquiry was performed to assess the possibility of adopting the philosophies of the LM tools/techniques which are directly related to the geometry. Generic questions were posed as criteria which were a result of the authors understanding of the topic, as seen in Figure 2.4 to make a selection of the lean manufacturing tools that could be adapted in to design.

A SELECTION OF LEAN MANUFACTURING TOOLS AND TECHNIQUES	
Standardised work	Just in Time
Andon	7 Wastes
5S	Takt time
SMED	Kanban
Poka-Yoke	Value Stream Mapping
Visual Management	Autonomation
Standardised work	Kaizen

Figure 2.4 A selection of Lean Manufacturing tools/techniques

In summary, Lean Manufacturing techniques focus on eliminating of waste and non-value-added activities. Agile Manufacturing techniques enable us to detect and respond to uncertain changes of markets and business environments. Additionally, Agile Manufacturing is strongly related to customer satisfaction and rapid adaption or change of products than Lean Manufacturing (Gunasekaran 2001). As this research is about customised and configurable products with the aim to improve the customer order process and become more responsive to quickly changing customer and market needs, Agile Manufacturing is better suited as collective term for the sub-components lean manufacturing concept and lean manufacturing method which are investigated in this research. Furthermore, the topicality of Agile Manufacturing naturally provides a better link to recent information and communication technology which is seen as a key factor for successful implementation and application of Agile Manufacturing (Xiaoli and Hong 2004; Wang and Koh 2010). The need for the development of an appropriate communication concept also played an important role in this case study, which confirms the decision to implement a manufacturing concept from the group of Agile Manufacturing techniques.

Whereas Lean is related to a higher efficiency of production and use of material, Agile enables more flexibility of the production and overall organisation to examining the capability of Lean and Agile manufacturing techniques to address the needs of wind turbine manufacturers.

The principal purposes of the production method ‘Just-in-Time’ are the reduction of inventory stock and production lead times. Lowered inventory stocks lead to cost reductions in the form of a reduced need for working capital. Also, flexibility is increased with regard to the short-term readiness for delivery (Meybodi 2003). This supply chain aspect is independent of the number of product variants.

Similar results are achieved by Standardization. Costs are reduced by orders of large quantities (economies-of-scale), less material overhead and spontaneous resupply, which in turn improves flexibility (Anderson 2004). The aim is to use as many similar parts as possible for many different sub-assemblies. Standardization requires a detailed and structured bill of materials, which in turn promotes the handling of product variants.

Modularization considers the whole product and the functionality of its sub-assemblies. The sub-assemblies are separated according to their functionality. This requires a more holistic view of the product and an understanding of its market requirements (Feitzinger and Lee 1997). The function-based definition of the sub-assemblies is well suited for the generation of product variants. A reduction of inventory is only achieved in combination with advanced business and production processes.

Kanban puts the main focus on the reduction of inventory stock. However, this method also aims to accelerate the production processes by an improved material flow and a guaranteed delivery date for materials (Ohno, Nakashima et al. 1995). Costs are lowered by the reduced inventory stock and the corresponding lower need for working capital. The acceleration of the production processes and reliable material delivery dates increase productivity. A Kanban system is independent of the number of product variants.

The core target of Kaizen, a zero-mistake objective throughout the whole enterprise, increases productivity and quality by avoiding mistakes (Imai 1986). In addition, the avoidance of failures leads to a reduction in rework and post-processing costs. Kaizen aims to influence the organizational attitude and may be applied to both a low and high number of variants.

Total Quality Management moves customer satisfaction to the centre of an enterprise's activities. Also central are the quality of the products and the flexibility of the enterprise in terms of how fast it can react to changing customer wishes. These quality and flexibility aims are achieved through improved production processes and optimized product development processes (Fox 1994). That is positive, in terms of managing many product variants. Total Quality Management is not purely focused on a low inventory stock; by aiming to improve production processes it automatically contributes to efficient production and a certain level of inventory reduction.

Using Concurrent Engineering, the final product quality is already positively influenced during the product development phase. This aim is achieved by the avoidance of construction-conditioned failures that could lead to raised costs due to necessary rework during the later production phase (Savci and Kayis 2006). This supports an improved and more efficient production. However, there is no direct focus on inventory reduction. The quality perspective alone does not support the efficient handling of many product variants during the product development phase.

Computer Integrated Manufacturing leads to higher productivity, as well as raised quality and flexibility, due to the integration of all information flows in an enterprise (Blecker and Kaluza 2003). Productivity is increased by shorter processing times as a result of the improved information flow. Furthermore, cost reduction is achieved by lower inventory stock, resulting from the improved material flow. Good information flow also allows a higher level of flexibility in production and with it the improved ability of the enterprise to adapt to changing customer requirements. Good information flow is also a good basis for the handling of many variants during product development, even if Computer Integrated Manufacturing does not provide a direct approach for the managing of product variants in a company´s value chain.

Mass Customization is realized by upfront engineering of product platforms and add-on options (Gardner 2009). This creates a strong capability for the managing of product variants. The clearly structured and market-aligned product design allows a reliable product configuration in the earliest product phase. This leads to efficient material and production planning. Along with others, Feitzinger and Lee (1997) define reduced inventory stock and material waste as main benefits of Mass Customization.

The key for a successful implementation of Postponement is the design of product platforms that delay the completion of production until customer orders are received. By doing this, it is easier to plan the inventory and lower the risk of products being made to stock. Product platforms designed for Postponement are not automatically best suited to an efficient handling of product variants. However, the Postponement design approach does provide a good basis to consider product variants as well.

So far in this literature review a number of themes such as product development, knowledge sharing, rapid prototyping, product innovations as well as Lean manufacturing are reviewed; and it’s evident that these themes have a significant influence on the organisational processes and practices.

Additionally, since this research study aims to examine the whole of supply chain which will have customer-supplier links within the organisations and external customer-supplier links; it is important to study the current literature on supply chain and themes relevant to it.

2.9. Perspectives of Supply Chain

As pointed out by Teuteberg and Wittstruck (2010), supply chain as a concept has continuously evolved. However, within the last twenty years it has become quite a popular phenomenon in the academia, and as such, academics across various fields have developed huge research interests underpinned by the desire to:

- Understand the concept deeper
- Suggest empirical ways of maximizing its application, particularly in the construction industry,
- Seek ways to proactively engage as well as mitigate current and perhaps perceived potential challenges of rapid climate change, ensuring environmental sustainability and growing public interests in ecology in the best interest of the construction sector.

The concept of supply chain evolved from purchasing, as it was then known, to the current academic study of supply chain management, and it has grown in popularity within the last two decades (Farmer, 1972). This growth in popularity has continuously attracted contributions from scholars across different shades of academic disciplines like operations management and organizational behaviour (Delfmann and Koster, 2005). Furthermore, the increase in the popularity of supply chain concept is evident in increased practitioner and academic journals, supply chain conferences and university courses in the area (Kelvin et al. (2006), resulting, to a large extent, in the multiplication of definitions about supply chain. According to Cousin, D. P. et al. (2006) and Kraljic (1983), the academic debate has increasingly metamorphosed from practical technical elements like transportation, logistics/operations management to something rather more focused as strategic business nature of supply chain.

Interestingly however, despite the increase in academic interest on supply chain concept, though partly occasioned by the introduction of lean manufacturing (Womack et al, 1990) which refocused the study, and lean supply which crystallized on the constraint caused by supply chain activities (Lamming, 1993; Rich et al, 1997), there has been a near equal rise in the profile of purchasing within the context of being a critical function of the firm. Therefore that, it has not been readily become known as a concept of its own. Supply chains in itself therefore is simply defined as a series of steps organizations link through single or multiple upstream and or downstream flows of products, finances, services and most importantly information from an initial source to a target customer (Trent, 2008).

Another scholar argued that companies with large and complex businesses who produce multiple products would normally use multiple supply chains (some more complex than others) to achieve their raw material objectives with the view of meeting customer's needs, hence, influencing an earlier realization by supply chain organizations that, meeting customers' needs is the key to sustained income flows (Wisner, 2009; p.6). Accordingly, supply chain was defined as the point at which a firm extracts raw materials, such as iron ore, from the ground and begins the process of selling those raw material to raw material suppliers who are responding to purchase orders and specifications received from component manufacturers who in turn develop these raw materials into usable products to meet the needs of target customers (Wisner, 2009) Simply put therefore, supply chain is a chronological and sequential connectivity between facilities and activities with the sole aim of supporting the production and actual delivery of goods and services to the final user (Cholette and Venkat, 2009) This sounds too simplistic, although easy to understand, considering the inherently interwoven and complex nature of the phenomenon been discussed. Although, not all supply chain usually includes all the stages.

2.9.1. Supply Chain Management

In 1989, Stevens provided an explanation of supply chain management and explained that it occurred in four stages, as in Figure 2.5. The figure shows that the first stage was to move away from each activity working in isolation within an organisation to functional integration stage. The next stage was to combine the key activities to move towards internal integration stage. Lastly, by involvement of suppliers and customers outside the organisation the stage of external integration was reached and therefore the emergence of what is referred to as supply chain management.

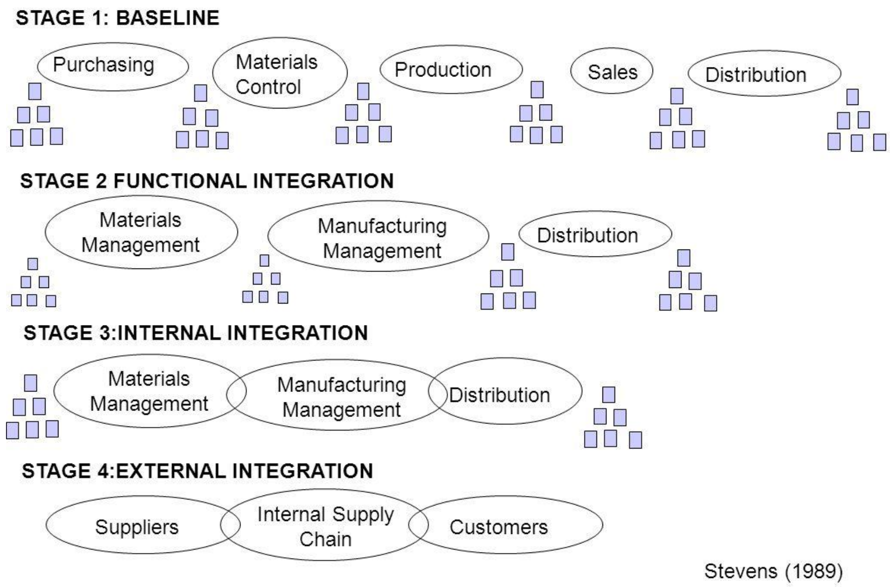


Figure 2.5 Supply chain Integration G. Stevens (1989)

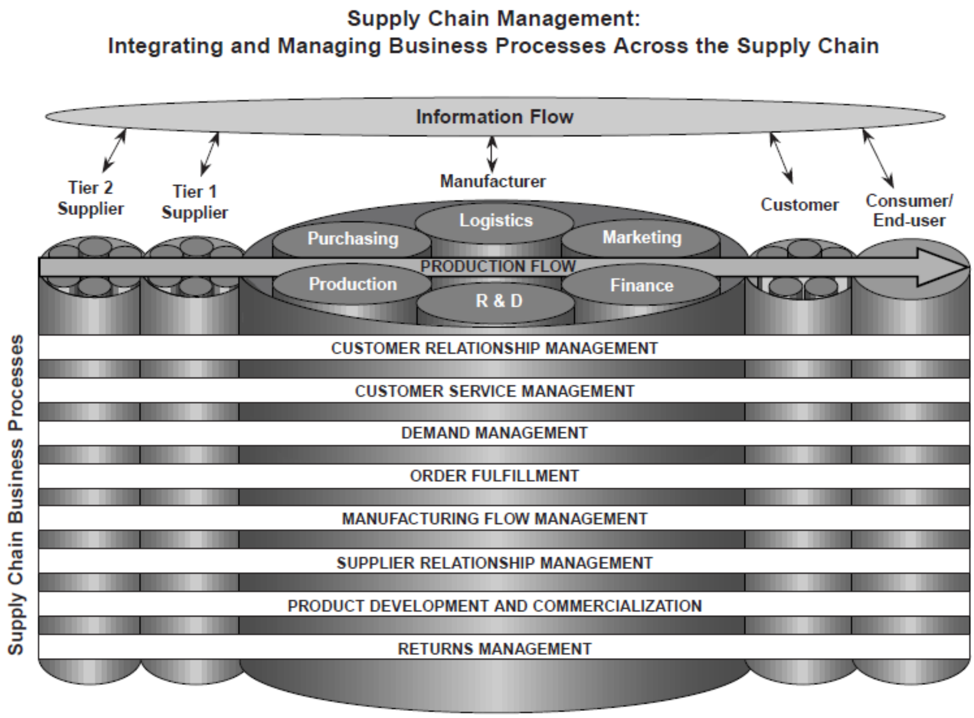
While most companies understand the overall concept of the supply chain management as integration of activities and processes and working with customers and suppliers (Figure 2.6), there are supply chain integration challenges. Awasthi, and Grzybowska, (2014) had identified total of seventeen factors acting as barriers affecting the integration of business functions in the supply chain (Table 2.1). These authors had analysed these barriers further and identified five as top five barriers as having major impact on integration of supply chains - lack of resource sharing (integration), lack of organisational compatibility, lack of information sharing, lack of responsibility sharing, and lack of planning of supply chain activities as top five barriers in supply chain integration. There are opportunities for organisations to commit resources to resolve issues to adopt flawless integration across the relevant supply chains.

Over the last few years the terminologies such as “demand chain” and ‘’value chain” have been used to represent and describe supply chain management, which has simply demonstrated the significance and importance of the subject matter. However, irrespective of how different authors in literatures describe, the core message of supplier up to the final customer through different stages remains. Supply chain management operates in a multiple dimension for which downstream refers to rolling towards the customer like supplier, factories, warehouses, distribution centres and retail outlet, and the upstream refers to reversing the process backwards towards the initial suppliers through different stages (Cholette and Venkat, 2009).

	Factors affecting the integration of the supply chain
1	Information sharing
2	Coordination
3	Trust
4	Willingness to collaborate
5	Communication
6	Common business goals
7	Responsibility sharing
8	Planning of supply chain activities
9	Flexibility
10	Benefit sharing
11	Joint decision making
12	Organizational culture
13	Organisational compatibility
14	Resource sharing (integration)
15	Top management support
16	Technological readiness
17	Training

Table 21 the factors affecting integration of the supply chain

Additionally, as a positive and 'outside the box' thinking research into supply chain management has also focused on concepts such as Total Quality Management (TQM) and Just-in-Time (JIT) to define the relationships with supply chain management practices (Cousin, et al 2006).



Source: Adapted from Douglas M. Lambert, Martha C. Cooper, and Janus D. Pagh, "Supply Chain Management: Implementation Issues and Research Opportunities," *The International Journal of Logistics Management*, Vol. 9, No. 2 (1998), p. 2.

Figure 2.6 Integrating and managing business process for the supply chain Management

The concept of supply chain management was first conceived and introduced by business consultants from Booz, Allen and Hamilton (Oliver and Webber 1992). Subsequently, scholars with different professional interests and academic backgrounds made permanent contributions which have further helped to crystallize the understanding of the concept with relations to inter-organizational management of different product flows (Heikkila, 2002; Frazier, 1999). Consequently, Delfmann and Koster (2005) have argued that, the concept of supply chain management can be better understood through three different perspectives, that is, economic, social-economic and strategic perspectives, which explain or validate the existence and management of supply chains. Follow-up to the above and based on different complexities and difficulties in conceptualizing and clearly defining the term supply chain management, it has resulted in an uncertain and confused theoretical underpinning and therefore unclear how the various research methods used really contributes to shaping supply chain management as a concept (Kelvin et al, 2006).

It is clear, that supply chain management does not stop with the supply of materials or products to potential buyers, but that it also entails ensuring that the end user customer receives the finished product in a systematically pre-designed and pre-planned manner. Some Academics have continually defined and attempted to redefine the concept of Supply Chain Management, but there is still disagreement on a universally acceptable definition. In some ways, most of the definitions tend to reflect one sided view underpinned by a particular academic or professional and sometimes around practical experience of such commentator. Therefore, laying the foundation of consistency, lack of coherence and impact as well as knowledge expected of a fully-fledged academic discipline (Cousin et al, 2006; Storey et al, 2006; Burgess et al, 2006 and Croom et al. 2000). Understandably, therefore, some of these definitions tend to reflect some forms of contextual biasness, hence lack universal applicability. Overall, academics from different fields keep projecting different definitions on the concept of supply chain management, possibly with the sole aim of maintaining either their relevance or the relevance of the field.

It can be argued, supply chain management is developing a wide range of knowledge base, however, that the multiplication of literatures and academic views will either benefit the discipline or suffer some obstructions because of lack of coherence in its literatures and different fragmented theoretical underpinnings or viewpoints. Despite all these apparent fragmentations and differences in supply chain management literatures, researchers from different disciplines supported by diverse research knowledge, have been able to find a common research ground, in management science, on the practice and study of supply chain management (Pfohl, 2000; Delfmann and Koster 2005).

In fact, it is largely believed that, supply chain management has gained international eminence, both as partial academic discipline along with its various conceptual debates and as a professional practice, which has seen the academics and industry practitioners reaching a compromise that it has become a vital and relevant aspect of management sciences (Cousin et al, 2006). Since the emergence of supply chain management, academics have continually attempted to advance theories and practices in order to develop approaches upon which to support further research studies (Pualraj and Chen, 2004).

However, academics such as Croom et al. (2000) speculate that, despite huge debates on the field in the last two decades, supply chain management appears to be a problem domain, therefore may not have developed enough to be recognized as a discipline, hence, lots of other disciplines are attempting to claim ownership of the field (Burgess et al, 2006). Unfavourably commenting therefore, one possible reason why supply chain management appears to have failed to be recognized as a full discipline and a problem domain could be hinged on the fact that most researchers, academics and practitioners in the field have not exhibited total and complete commitment to ensure the achievement of such recognition. This is because, most of those who are leading the research on supply chain management have their backgrounds in other academic and professional fields to which they seemingly hold their first and unflinching loyalty, hence the associated complexities and lack of agreements in definitions and debates (Burgess et al. 2006; Croom et al. 2000).

Following on, academics like Cousin et al. (2006) and Storey et al. 2006) argue that supply chain management is still in the emergence stage using the measurement “test criteria” of quality, coherence, debate and impact, therefore cannot yet be classified as a full “discipline”, though they gave credit to existing formidable body of knowledge across different areas of the field, which still lacks coherence and impact. Additionally, Storey et al. (2006) concluded that there exist huge gaps, caused by a range of barriers, between developed theories and what is actually taking place in the practice of supply chain management, thus lacking in theoretical view and empirical strictness. One early theory proposed by academics is the configuration school of thought, which could be characterized as the syntheses of contingency research because it attempts to integrate fragmented insights inherent in other stand-alone contingency literatures, which basically focuses on dependent and independent variables like understanding the relationship between the size and formalization of an organization (Kim-berley, 1976; Meyer et al. 1993; Delfmann and De Koster 2005).

It is possible, advocates of this though are more social constructivist and subjectivists who are mostly driven by their biasness expressed through their scientific and practical underpinnings (Miller, 1999), rather than positivistic and realistic underpinnings (Delfmann and De Koster, 2005; p.13). Additionally, the configuration theory has fundamental bearing to both supply chain and logistics; therefore the proponents demonstrate double loyalty certainly not in the best interest of supply chain management. Therefore, opposing research interest has become one of the reasons for the evident gaps observed in knowledge, literatures, impact and coherence informing the fundamental delays in achieving a full discipline standing for supply chain management.

Furthermore, other theories that followed the configuration model with inherent affinity were proposed by Christopher Martin and Towill Dennis (2001) who suggested an integrated twin model for the design of lean and agile supply chains as well as the Triple-A supply chain (Lee, 2004). Although not explicitly stated, the assertions of these later approaches share some common elements with the configuration school therefore reflecting an integral or synthetic perspective (Dennis and Martin, 2001; Lee, 2004). Converse to the difference in theories and knowledge as well as empirical and theoretical gaps observed; supply chain management has been recognized as beneficial to the overall strategic business functions carried out by quite a number of excelling companies in Europe (Delfmann and De Koster, 2005).

However, previous definitions have concentrated on a more functional and pragmatic viewpoints like, purchasing, logistics and marketing and creating postponement through supply chain management (Delfmann and De Koster, 2005; Mentzer et al. 2001), recent contributions present frameworks that will serve as answers on how to design and manage particular relationships that exists between various divergent supply chain stages but, apparently neglects addressing the relevant theoretical underpinnings (Delfmann and De Koster, 2005). This is yet another confusion in debates that is holding supply chain management back as a full academic discipline. However, a number of contributors have suggested how to possibly address supply chain management theoretically (New, 1997; Jackson, 1997 and Logan, 2000;

Delfmann and De Koster (2005). Furthermore and supporting the socio-economic perspectives and other literatures, Cooper et al. (1997) argued that supply chain management could be defined as a process that seeks the re-arrangement of carefully identified business functions focused in such a way that it could achieve customer orientation.

Harland (1996) described supply chain management as an attempt to manage a rather complex network of interconnected businesses whose main aim was to provide services and products required by the end user. Clearly, this definition lacks depth and too macro in its outlook because, it failed to show that supply chain management does not essentially deal with complex network of interconnected business concerns but somewhat the interest of the potential customer remains its overall driving force or aim. Therefore, supply chain management will normally seek to effectively manage the stages of identifying, sourcing, designing and striving to continually meet all the customers' needs through the supply chain processes, without overlooking the effective and efficient management of the total delivery process within any social, environmental, economic and or political instance with the view to constantly achieve a balance (Elkington, 2004) both for the organization and the customer.

The complexities and difficulties in contextualizing the definition of supply chain management to fit the academic purpose of this research are raised to another level of complexity with operations management. Operations management definition which addresses product development, product distribution and customization as well as balancing demand and capacity requirements, (as it concerns transforming raw materials into finished products ready to be delivered to the final customer (Lee, 1993)), is adopted to play a focal point because, it obviously fits the strategic purpose and focus of the research where it looks into how innovations within the various different intra-chain stages of supply chain management could potentially deliver sustainable construction sector. Additionally, this obviously has a bearing on specification driven demand and capacity requirements as it concerns getting and transforming raw materials into finished products and services and ensuring the finished products meet the needs of target customers and are finally delivered securely to them. However and for argument sake, the logistics discipline advanced yet another different strand to supply chain management definition. It viewed the concept as “an integrative philosophy designed to manage the total flow of a distribution channel from the supplier to the ultimate user” (Cooper et al. 1990), paradoxically, this definition is not fundamentally and completely different from the previous ones, so why the confusion and disagreements amongst academics by insistently giving discipline specific definitions of supply chain management without relevant theoretical backings.

Despite these definitional predicament, Christopher (1998) and Harland (1996) concluded not to recognize supply chain management as a vertical pipeline linking (Delfmann and De Koster, 2005) organisations with different business experiences and expertise together for the common goal of delivering raw and human materials to other firms through their production processes with a view to meeting the needs of target customers. Rather, Harland (1996) believes the field should be viewed as managing network of interlinked businesses mainly involved in the provision of products and service packages that could be required by the end customer; therefore it is a process that manages a complex network of inter-related organizations involved in exchange processes. On his part Christopher (1998) argued that, the name should be recalibrated and the word “chain” changed and replaced with the word “network” because there are usually numerous suppliers and customers as well as suppliers’ suppliers and customers’ customers and finally drew two contradicting conclusions. Firstly, that the whole field should rather be called “demand chain management” to demonstrate that demand from the market should be allowed to drive the chain, or better still that, the term supply chain management should be left simply because it has seemingly gained wide recognition (Christopher, 1998; Lambert et al. 1998) amongst scholars and practitioners alike.

Critically speaking, most commentators on supply chain management appears to be more driven by the need for self-preservation and have been mostly observed to be subjective rather than been objectively innovative by allowing empirical research findings and theory reinforce their attempt to redefine supply chain management concept. Therefore, it could be argued that the initial definition advanced by Lee (1993) stands to be more relevant, although it also suffers from lack of relevant theoretical underpinning (Delfmann and De Koster, 2005) but it succinctly covers the core of the matter which is product development, product distribution and customization as well as balancing demand and capacity requirements as they may affect transforming raw materials into finished products ready to be delivered to the final customer.

Lately, supply chain management has become an important strategic focus of competitive advantage to organization and businesses (Harrison et al. 2003) in their bid to maintain product quality, better customer service and cost reduction. In other for organizations to achieve these objectives, they should be able to effectively co-ordinate products, information and funds which are the three types of flows that moves upstream and downstream within the supply chain process (Harrison et al. 2003). However, the ability to effectively coordinate these three flows is the focus of supply chain management (Harrison et al. 2003). The strategic focus of supply chain management according to Harrison et al. (2003) covers supply chain design which determines and also drills down on supply chain infrastructures such as distribution centres, plants, transportation modes and lanes as well as production processes needed to meet the demands of target customers.

Therefore, the ability for organizations to achieve the above objectives critically depends on creating effective and efficient information infrastructure that will constantly interface with members of a supply chain, although this has often been a difficult strategy to create (Gavin, 1988). Questionably therefore, achieving any form of sustainable construction sector is inherently tied to an organizations acceptance of the relevance of an adequate and efficient information infrastructure that satisfies and seeks to accommodate members with divergent levels of sophistications and expertise in information technology, provide a wide range of functionality varying from simple data transmission, access to application and finally, the organization's ability to accommodate a constantly changing quantum or mass of suppliers and consumers at different relationship levels (Upton and McAfee 1996; Harrison et al. 2003). Theirs was an attempt to interlink technology to the current practice and potential success of supply chain management. Accordingly however, Harrison et al. (2003) cautioned that, the suitability of an integrated and effective information infrastructure and perhaps other potential infrastructure technologies should be measured based on how well they fill and complement necessary gaps.

This information infrastructure strategy resonates with, for example, the most widely used Electronic Data Interchange (EDI) for connecting suppliers to manufacturers (Goldman Sachs Investment Research, 2000). Although, key major disadvantages pointed out in the use of (EDI) are the large up-front investment needed and significant cost of maintenance as well as the difficulties in justifying the early usage to assess supplier's capability at the start of supplier-buyer relationship (Harrison et al. 2003). Since this is not a technical drawback, it is suggested that large conglomerates with diverse and complex supply chains interplay, like the construction sector, should adopt necessary information infrastructure strategy, like (EDI), with a view of creating transparent and competitive global raw material or products sourcing network, that could arguably, strengthen and deliver a sustained construction sector in the twenty-first century.

Furthermore, other academics view supply chain management as an umbrella process that could effectively manage overall business improvement (Poirier, 2005) efforts. Consequently therefore, three strategies were suggested, such as, end-to-end processing with the focus for higher customer satisfaction through the synchronization of all process steps to a best-practice stage, secondly, through collaborative use of cyber technology (Poirier, 2005; Upton and McAfee 1996; Harrison et al. 2003) and thirdly establishing the scope of ensuring advanced improvement efforts (Poirier, 2005).

In the main, supply chain management does not only concentrate on the external business interactions between organizations and suppliers but also focuses on the internal functional complexities that operates within the organization itself like, timely movement of raw materials from warehouses to factories and effectively managing the production processes within the organization including quality control, packaging and final output and delivery to target customers (Harrison et al. 2003; Poirier, 2005). Despite the persistent confusion caused by commentators who try to define supply chain management, either as a philosophy or as a set of operational practices with a single term, there is a near consensus that supply chain management involves proactively managing the two-way movement and coordination of goods (Trent, 2008), information (Upton and McAfee 1996), services and funds (Harrison et al. 2003) from raw material stage to the final customer product through an effectively synchronized coordination that cuts across organizational boundaries (Trent, 2008).

2.10. Supply Chain Innovations

Generally, innovations constitute one of the hottest business topics of discussion today, and have consistently reverberated in the strategic planning processes across organizations (Trent, 2008). It basically cuts across all facets of human life and businesses. For example, research findings in pure and natural sciences, humanities, arts and social sciences continually discover better and innovative principles and theories that have underpinned human existence, particularly in recent times like, innovations in telecommunications (smart phones), hybrid cars, green buildings and even innovative ways have been discovered to increase access to education and knowledge as well as innovative ways of sustainable living in the environment. Therefore, it is no doubt that innovative supply chain processes could contribute to delivering sustainable construction sector.

Consequently on the above and within the context of this research work, innovation is viewed as introducing new or unique idea or method with the key aim of sustainably improving all supply chain processes (Trent, 2008). Furthermore, there is the need to adequately manage "lean" across the process of supply chain because lean and innovation are not necessarily mutually exclusive from one another (Trent, 2008). They are technically two sides of the same coin because, eliminating waste from within the supply chain process could trigger new and out of the box ideas that might lead to innovative new methods and techniques across supply chains that could ultimately contribute to the creation of a sustainable construction sector.

Just as the clamour for new innovations in supply chain raged on, Fisher (1997) suggested a framework that could possibly determine a strategic fit between functionality and innovativeness of an organization's product to an efficient and effective supply chains. Information technology has become a major area that can radically influence innovation in supply chains. Indeed, information technology should be viewed as an enabler to achieve distributed way of working across inter-organizational systems that have led to new IT developments such as EDI, XML, web services and service oriented architectures which has allowed networked partners to ventilate information and coherently and timely coordinate their activities that has made concepts like just-in-time delivery a success (Tan et al., 2011). Therefore, it could be argued that, if stakeholders want an innovative supply chain that could deliver sustainable construction sector, then adequate research must be devoted to the area of information technology. Therefore, supply chain itself can only be considered as innovative when underpinned by strategic infusion of modern technological know-how that will help drive the process and create a sustained interlink with all relevant stakeholders.

According to Shapiro (2009) modelling technologies will allow managers manage data more effectively in their companies thus creating rationality in supply chain network. Shapiro had further suggested that, organizations should use the Enterprise Resource Planning Systems (ERP) software and hardware which would normally influence the creation and flow of transactional data of the organization as it concerns human resources, finance, manufacturing, logistics and sales through an integrated uniform system environment that can access a centralized data base (Shapiro, 2009). This would be, if adopted by organizations, an innovative approach to supply chain. Although this software has had some poor results at the end of 1990s occasioned by imposed conformity and different levels of hidden costs and so, it has largely recorded sustained usage and adaption by large companies were worldwide sale of this software exceeded $20 billion as at 2003 (Shapiro, 2009). In what appears to be information technology driven strategies for innovating the supply chain sector, Shapiro (2003) further defended the adaption of Transactional IT, that basically eradicates and mitigate underperforming human efforts, and Analytical IT, which integrates supply chain decisions across managerial responsibilities and planning levels by organizations seeking to innovate their supply chain sectors. This strategy resonates with today's IT driven twenty first century which organizations should take advantage of if they wish to drive down overall operating costs and close raw material gaps, particularly in the construction sector.

Furthermore, another commentator suggested that, organizations should harness the advantages inherent in the "concept of collaboration" as new innovations, arguing that, this will add value and innovative technique to organizational supply chains and assumedly could create a sustainable and innovative solutions to obvious challenges (Christian et al. 2012), which is consistent with Williamson's (1985) and Christian et al (2012) argument that organisations generally co-operate as well as compete with each other, although, such forms of collaborations are influenced by divergent global cultures and organisations (Kanter, 1994). Therefore, the extent of collaboration is basically determined by an organization's ability in finding the right and exact balance between co-operation and competition (Williams, 1985; Christian et al 2012; Jorde and Teece, 1989).

Another innovation in supply chain is pinned down to the involvement of suppliers in the initial development stage of a product (Modi, 2006), within the context of this research, initial stages in the construction sector would entail, architectural design and project lay out as well as choosing the exact materials needed for different stages of a specific construction project factoring cost and accessibility into the supply chain equation. This will understandably lead to sustainable construction and mitigate or completely eliminate the possibilities of delays in sourcing quality raw materials as well as compression of supplier's delivery time and space. Particularly, Gerwin and Barrowman (2002) have provided extensive literatures on inter-functional coordination within an organization for effective product development, stressing that initial design and development of a new product should not be the exclusive preserve of the originator of the idea, but rather, it should involve an inter-functional coordination with organizations. Therefore, the construction sector should create strategic multi-functional coordination between it and the raw material supplier to bring innovation into the supply chain sector that could possibly trigger a sustainable construction sector.

It is argued that, inter-functional coordination should be in the form of joint product development (Burt and Soukup, 1985) between the supplier and the manufacturer, an example of automobile product development practices (Clark and Fujimoto, 1991) where suppliers are seen to be deeply involved in the manufacturer's research and development design stage, the findings showed that allowing raw material suppliers to get involved in initial product and planning stages have a positive impact on the overall project lead time and cost (Modi, 2006). Many examples of the wide success of the supply chain and manufacturer inter-functional strategy are resonated across United States, European and Japanese automobile (Bonaccorsi and Lipparini, 1994) companies which provides the impetus for suggesting same to be adopted for the construction sector to help position it for sustainability (Turnbull et al; 1992; Wasti and Liker, 1999; Modi 2006).

Consequently, it was observed that significant efforts have been expended by researchers to identify key benefits associated with involvement of raw material supply chain to a business and or product initial design stage, for instance, the success recorded in accelerated product development time occasioned by the early involvement of suppliers in the computer industry (Eisenhardt and Tabrizi, 1995). Other examples include creation of competitive advantages which is strategically critical for organizations success and also leads to higher quality and possible access to modern technologies when suppliers are integrated with organization's research and development stage (Ragatz et al, 1997).

Interestingly, other experts further identified key elements of supply chain integration which they further divided into internal and external constructs (Vickery, 2011). This meant that, whichever supply chain innovative strategy (whether designing with suppliers, collaboration amongst businesses or modelling technologies like-ERP software and hardware) adopted by organizations, their functions and perhaps potential success, should be viewed from both internal and external perspectives

(Vickery, 2011). The internal integration construct (which represents horizontal internal supply chain) synchronizes internal functions such as research and development with marketing and sales (Ayers et al 1997; Flynn, et al 2011) and often other departments like manufacturing and purchasing (Narasimhan et al. 2001; Modi 2006). On the other hand, external integration, being what scholars often pay most attention to would typically involve inter-organizational business relationships such as purchasing with business planning as well as sharing performance management information amongst two or multiple firms (Barratt and Oliviera, 2001).

2.11. Research and Development

The above discussion on early involvement of supply chain in organization's research and development stages along with the attendant benefits associated with it brings to the focus the relevance of research and development to this thesis. Curiously and within the context of the research aim, what role can research and development play in determining new innovations in supply chain in an attempt to enhance the delivery of sustainable modern construction sector. Basically, research and development is viewed as the ability of an organization and or its professional body to gain more strategic advantage in the market and or industry through new innovations driven by adequate funding of research and development activities.

Therefore, it could be argued that achieving a sustainable construction sector is fundamentally dependent on the interest, organizational funding and time invested by academics and perhaps practitioners of supply chain management with the view of evolving new principles and theories as well as guidelines that will add value to supply chain activities. If this is done sooner, it would introduce as well as infuse new ideas that could lead to innovations in the practice of supply chain and supply chain management with a possible snowball effect on sustainable construction sector. Arguably therefore, research and development could be a critical element necessary for guaranteeing a sustainable construction sector. Investment in research and development should be considered by supply chain firms as a critically strategic business development plan for the twenty first century. This is particularly necessary in construction because of the continuous changes in competition and fluctuation in manufacturer's preferences as well as new typographies occasioned by the impact of climate change on built environment. Therefore, a supply chain organization wishing to go it alone and remain in business should invest massively in research and development or on the other hand consider strategic alliances and perhaps acquisitions for it to stay competitive.

The universally acceptable definition of research and development emphasizes that, it is a demonstration of creativity that is systematically and persistently undertaken with a central focus or view of increasing bundle of knowledge (in business, culture, society, strategy and human knowledge) that will be used for divergent new applications (Bosworth et al. 1993). One thing that has been observed about this notion, however universal the current definition might sound, is the fact that some countries skew the definition to suit their best parochial interest. For instance, the United Kingdom authorities prefer to adopt an earlier international definition which views research and development, as 'creative work that is systematically engaged in on the bases of contributing and increasing the bundle of scientific technical knowledge and with a view to use this new knowledge to invent new practical applications' (Bosworth et al. 1993). Consequently therefore, research and development succinctly put is 'the presence or absence of an innovative or novelty element, which must break new grounds,' and this is basically the guiding parameter that distinguishes research and development activity from non-research activities (Bosworth et al. 1993).

Furthermore, the above definitions clearly suggest that the key to applied research activity is demonstrated through the invention of new knowledge and new technologies (Bosworth et al., 1993; Frattini and Cheisa, 2009). However, to be more precise and thorough according to Frattini and Cheisa (2009) research and development as an umbrella concept carries within it three main elements such as basic research, applied research and new product development. But the operational divergence in these concepts Frattini and Cheisa (2009) argues is expressly reflected in their descriptive definitions. They opined that applied research focuses on the generation of new knowledge required to fulfil specific explicit need and meet industrial application while new product development (NPD) research consists of heterogeneous tasks, such as prototyping, after-sales-services and engineering, that are relevant to apply existing bodies of knowledge to the development of new product or services, whereas basic research principally focuses on creating new knowledge about the principles underpinning natural and social phenomena without direct relationship with industrial application for example, industrial processes and new product (Frattini and Cheisa, 2009).

Although these three elements constituting research and development might sound broadly alike because they seem to share some common definitional partners, they are inherently and technically different. Obviously, knowledge-based companies which controls critical abilities and technologies has replaced the former industrial machine-led model of productivity (Frattini and Cheisa, 2009), thus supply chain has to invest in research and development (to improve engineering and after-sales-services as well as industrial processes and new products) to remain competitive in the body of knowledge and supply chain business. This is because the previous gaps between new or subsequent product innovations or inventions have been compressed and shortened, resulting in a larger number of new services and products introduced into the market and to organizations over time (Bayus, 1998). However and despite the importance of research and development projects to business competitiveness, quite a number of firms, especially new and high-tech companies, often lack the necessary collateral or tangible assets and performance pedigree (Berger et al. 1998) needed to raise the much needed capital for financing innovative research programmes.

Generally therefore, the central role played by research and development activities in both countries and businesses has been widely acknowledged across various areas like advancement in social welfare, products and services as well as science and technology (Frattini and Cheisa, 2009). Arguably, it is believed however, that most of the benefits from new technologies gained through research and development flows towards the customers, particularly because, the multiplicity of technologies could drive down commodity prices on the long run (National Academy of Sciences, 2002). This sounds right in principle but quite the contrary in practice, because an example in reality, lots of the new high-tech telecommunications commodities and automobiles and even the development of green buildings are way above the affordability of an average consumer, thus it could be argued that, new innovations apparently benefits the firm first, and a microcosmic number of high earning and privileged customers.

Another vital importance of research and development innovations is the contribution in the transformation of the "New Economy" which is basically underpinned and driven by information and the capacity to transmit, sell, exchange and ultimately instantly utilize such information through digital and or electronic mediums over international or local network connectivity, which is particularly evident in the global diffusion of computers and networking technologies (Rashkin, 2007) and this has compressed time and physical geographical boundaries. In particular, research and development innovations has given rise to advanced manufacturing (new tech products that mostly require quite sophisticated techniques like microelectronic-mechanical systems-MEMS) as well as Nano tech, which are basically small products that are manufactured at atom level, and even in agriculture (Rashkin, 2007).

2.12. Sustainability

In the business environment today, sustainability has become a common construct although, the concept has attracted as much definitions and conceptual contradictions as supply chain management have done. According to the World Commission on Environment and Development (1987) sustainability is "any development that meets current needs without compromising, endangering or eliminating the ability of future posterity to meet theirs". This is a generally quoted definition. Unfortunately, this definition is subjective and rather too broad because it does not capture or address the need and mechanism required for individuals and organizations to become more sustainable (Williamson et al., 2010), therefore, it could be viewed as lacking applicability. In an earlier attempt by Elkington (1998) to bridge future definitional gaps, advanced a more comprehensive concept for organizational sustainability within the context of the triple bottom line covering environment, economics and social goals. Further stressing that, right at the very centre of these activities (social, environmental and economic performance) which organizations involve in, they are socially and environmentally beneficial, and also creating competitive advantages for firms, and thus economically sensible (Elkington, 1998). But again, this sounds more of an economic relevance of the concept rather than addressing sustainability as the core of the subject matter. Other commentators like Cater and Rogers (2008) defined sustainability within the context of risk management, transparency, culture and business strategy and linking each of these areas with the triple bottom line (environment, social and economic) approach.

According to Michael Blowfield (2013) sustainability is actually demanding change and total society transformation in contemporary times just as steam age, electricity, printing and IT examples are attributed to radical innovations. However, sustainability has generated complex tension mainly because, if fully applied will cut right through the heart of human social-environmental interactions, by compelling people to make radical changes to their way of life in relation to how it affect the social, environmental and economic performance of their communities, with a view to bequeathing a habitable society to future posterity. This challenge affects what we produce and fundamental nature of prosperity as we currently know it (Blowfield, 2013). Within this context therefore, supply chain management must focus on addressing sustainability by ensuring that sources of raw materials and the supply chain are managed in an environmentally and socially sustainable way with a view to replenish the environment for future posterity.

Sustainable supply chain management can be viewed as managing information, materials, people and capital flows with the purpose of influencing the economic, environmental and societal life of a given community (Morana, 2013). This definition is slightly skewed from the one advanced by major proponents like Carter and Rogers (2008) who saw sustainable supply chain management as transparent and strategic achievement of an organization in terms of societal, environmental and economic goals in the most systematically transparent manner through effective coordination of fundamental inter-organizational business processes seeking to improve the long-term economic performance of a company's supply chain.

Furthermore, the need to effectively gauge sustainability in order to ascertain how organizations are achieving set milestones gave rise to the political context of the debate which is focused towards achieving a policy shift in the direction of designing sustainability indicators which is currently been championed by the United Nations, individual national government as well as non-governmental organization (NGOs) (Smith, 2002). Therefore, the capacity to secure sustainability critically rests in the door step of public policy makers who must draw their evidence from scientific findings as well as demonstrate deep understanding of diverse human values and goals (Smith, 2002). Underpinned by the above facts, Bossel (2000; Smith 2002) argues that whichever sustainability indicator is developed, they must reflect two key elements, such as point out information on current state and viability of the particular system and also provide enough information about the contributions of the particular system to the overall performance of other related systems dependent on them. In other words, the ideal index indicator of sustainability should be a rather simplistic, composite numerical measurement that is an easily understandable tool for a much more complicated phenomenon (Smith, 2002).

Another extension to sustainability which happens to be a precursor to the concept of sustainable development which is mainly believed to serve as answer to arriving at a more equitably balanced and synergetic relationship based on social, economic and environmental needs (Tladi, 2007) of people and individual organizations. Arguably though, sustainable development is believed amongst law commentators to be closely related to the evolution of international environmental law (Adams, 1990) as reflected in the Behring Sea Fur Seals disagreement between America and Great Britain as far back as the 1880s (Stands, 2000) hence therefore, international environmental law cuts across economic activities (Tladi, 2007). The concept of sustainable development throws up within it some critical moral issues like redistributive justice, how to equitably distribute and allocate the benefits accruing from natural resource use and who takes responsibility for financing the efforts towards environmental protection (Tladi, 2007). Interestingly, these ethical questions are given legal interpretations within the context of international law (Stands, 2000; Tladi, 2007) which further strengthens the argument often advanced by legal commentators that, sustainable development is interwoven with international environmental law (Adams, 1990; Tladi, 2007).

However, the question that has troubled most commentators is, the purpose of sustainable development and what it wants to achieve. It should be noted at this juncture therefore that, the sustainable development notion or construct grew out of the general realization and concern shown by humanity (Tladi, 2007) that the way and manner demonstrated by organizations (oil exploration majors, automobile majors) and countries (China, USA, Western Europe and recently India) in the use of global resources to foster their development is currently detrimental to the environment and the social needs of the indigents (Tladi, 2007) and if not responsibly checked, will bequeath an environmentally catastrophic world to the future generations hence, plunging the future generation into an avoidable pit of excruciating poverty and unsustainable economic, social and environmental development world (Elkington, 1998; Cater and Rogers, 2008).

Underpinned by the above fact therefore, the central purpose of sustainable development, according to Tladi (2007), is to encourage all stakeholders (including individuals, organizations, national governments and non-governmental organizations) to make or hinge all development processes and framework consistent with environmental and social considerations. Because currently, the insatiable need to develop driven by economic consideration is first considered and therefore takes upper slot before any environmental and or social thoughts. Therefore, humanity could be standing at a very dangerous edge in history, thus, sustainable development requires an aggressive paradigm shift from business-as-usual attitude currently been demonstrated by quite a number of leaders across the world who ought to be more pragmatic.

A robust attention should therefore be given to the poor as one key element of the new paradigm (The Founex Report on Development and Environment, 1971). Although the Stockholm Declaration suggests that attention should be given to environmental considerations, but, there are quite serious concerns on the need to improve and possibly better the quality of life of the indigents across the world (The Founex Report on Development and Environment, 1971), hence, this has been followed up with the UN global framework such as, 'Millennium Development Goals' (MDGs) by 2015, where countries are expected to achieve certain level of development, especially in the rural areas, in accordance with globally set parameters, with a view to providing and meeting basic needs sustainably such as, potable water, fertilizer and improved seedlings as agricultural inputs and education for the girl child to mention a few (Tladi 2007).

In a nutshell, Gechev (2005) further demonstrated attempts to recalibrate and modify the definition of sustainable development, stressing that realistically the development could only be sustainable when it can achieve a dynamic balance between ecological and social principles. According to Gechev (2005), the social aspect of sustainable development could include near perfect (re)distribution of public wealth through a transparent and near perfect mechanism, and if this is achieved, then sustainable development could be viewed as 'socially justified and environmentally sound economic development. On the other hand, Gechev (2005) argued that, an economic development is environmentally strong when anchored on the principles of priority use of intensive growth factors and substantially increased use of renewable natural resources and reduction in the use of non-renewable ones to mention but a few. Hence, economic development should be a precursor to economic growth (Gechev, 2005).

Conversely and in a twist of argument, he concluded that, it was practically near impossible to achieve sustainability of development when measured against quality of life and level of consumption, but of equal relevance are, the indicators to gauge how this could possibly be achieved regarding used natural resources and pollutants of the environment (Gechev, 2005).

2.13.Sustainable Construction

It is quite difficult to view the construction industry as one that is integrated and comprehensive, one reason could be because it is obviously multifaceted (Mather and

Cornick, 1999) given the different disciplines and persons who have to work together to deliver on any one particular construction project within a specific time frame. Hence, productivity in construction is generally viewed, due to traditional and practical reasons, as the total time needed to produce one unit of output, although the unit of output constantly varies determined by particular circumstance (Rojas, 2008), this excludes the possibility of a universal labour productivity definition to all construction circumstances (Rojas, 2008). Having said that, construction industry, according to legislation and Construction Industry Development Board Act of Singapore (1984; Ofori 1990) viewed construction industry as;

> "the industry which carries out construction works, in terms of construction, extension, installation, repair, maintenance renewal, removal, alteration, dismantling or demolition of any building, structure … road, motorway, harbour works, railway, cableway, canal or aerodrome, any electrical gas, water or telecommunications works, any bridge, viaduct, drain, reservoir, pipeline, sewer, shaft, tunnel or reclamation".

This definition is quite narrow compared to the one adopted by Ofori (1990), but it is in tandem with critical fundamental functions inherent in the construction industry. Although the Construction Industry Development Board (CIDB) went further to recognize 'planning, designs, supply of materials, financial services and construction related research and development' (Ofori, 1990) as other critical aspects of construction as well. This does not resolve the conflict being generated due to lack of acceptable definition for the concept of construction. However and for the purpose of his research, Ofori (1990) adopted a broad definition of construction to mean;

> "that sector of the economy which plans, designs, constructs, alters, maintains, repairs and eventually demolishes buildings of all kinds, civil engineering works, mechanical and electrical engineering structures and other similar works, … and the industry includes Professional consultants, Civil engineering contractors, Material and equipment manufacturers, Public agencies, Building contractors and Material suppliers and plants hire firms".

However and surprisingly, all published statistical data relating to construction industry referenced by Ofori (1990), are underpinned by the United Nations Department of International Economic and Social Affairs (1998, Ofori 1990) definition of what the construction industry should cover, such as the whole of construction activity consists of:

1. Construction industry proper: contract construction by general builders, civil engineers and special trades contractors;
2. Contraction construction carried out for others by establishments or organizations classified to industries other than construction;
3. Own-account construction carried out by independent units of enterprises or other organizations not classified to the construction industry proper;
4. Own-account construction carried out by establishments or other organizations not classified to the construction industry, with no independent construction unit; and
5. Own-account construction carried out by individuals. General indicators of activity (data on construction enterprises and value of work done) refer to units classified under (1) and (3) …"

Therefore, Ofori (1990) in his research did not quite rely on his attempted broadened views or singleness of his definition of construction industry, but rather followed the framework and practical definitional parameters set in the United Nations Department of International Economic and Social Affairs (1998) framework; and this points to the fact that, it will be hard to arrive at a universally acceptable conceptual definition. One could therefore argue that, it is mere nonsensical to attempt to craft and develop a universally acceptable definition for construction because there will always be 'country variations to anyone suggested' given that, countries are traditionally different and a large percentage of their views on concepts and issues are driven or determined by their national cultures, although there might be some international convergence.

Unfortunately however, the weaknesses observed in the construction industry of some middle-income countries (Iraq, Albania and Sudan) are quite unlike those of their developing (Afghanistan, Chad and Bangladesh) counterparts. For example, Arditi et al (1985) argued that, the Turkish construction sector was plagued with lack of such resources like, ‘qualified manpower, technical personnel, construction materials and equipment….’, to mention but a few. Therefore, the government of such countries and indeed of other emerging economies and even developed countries must sustain, and as a matter of urgency, evolve relevant policies and develop the necessary political fortitude to foster sustained growth in their construction sector.

For instance, in Singapore, the education ministry has been empowered to develop national curriculum that captures construction training into the schooling system right from the primary, secondary and tertiary levels to develop construction technicians and professionals (Ofori, 1990) and (1993), but the Construction Industry Development Board (CIDB) is specifically empowered to administer skills training, whilst working closely with the Public services Commission as central agency involved with the planning, administration of government scholarships bursaries from foreign donors (Ofori, 1990). However, it should be noted that the strategy of training a pool of construction professionals through specifically designed academic programmes and inclusion of construction into regular school and tertiary education curricula is not peculiar to Singapore alone, because the United States of America realized this gap in knowledge and skills and therefore adopted the same strategy (Rusk and Bhattacharjee et al. 2012). Finally, the critical aspects of the roles expected of (CIDB) and Ofori (1990) are such that they cover:

Promoting the development, improvement and expansion of the construction industry;

a. Facilitating mechanization;
b. Encouraging standardization, and the introduction of new, advanced technologies;
c. Assessing training requirements and implementing training programmes at all levels;
d. Promoting the advancement of skills and expertise of persons engaged in the construction industry
e. Promoting research”.

The seemingly clearly structured construction sector and the effective management and collaboration with other relevant sectors in Singapore arguably, gave it the accelerated development drive and achievement as well as increase in the per capital national income level of the citizenry within the last three decades.

Mather and Cornick (1999) suggested four principally distinctive members that make up the construction project team in terms of discipline, professions and or people; first, the client/project manager who represents the interest of the commissioning customers in terms of leadership, project requirement and direction (Mather and Cornick, 1999). The project designer who is responsible for the overall design focus and construction solution for the project is the second most relevant member of the team, and the third relevant person is the construction manager who galvanizes human and physical resources needed to achieve the end product, while finally, the specialist trade contractor who is mostly responsible the particular detail designs (Mather and Cornick, 1999) as well as other duties is the fourth important person in a typical construction project site.

Obviously, the above construction project team is skewed without the inclusion of raw material supplier, right from the conceptual and design stages (Modi, 2006), and collaboration (Christian et al. 2012) that could bring new innovations to how the project is executed and delivered as well as reduction in time of supply chains activities. This has been one key factor responsible for stalled projects and even poor quality delivery because raw material supply chains are not considered as integral part of the construction team and therefore a realistic analysis of sustaining raw material supplies from the immediate to the long run becomes a problem. Cornick (1996) believes however that, total improvement in the construction industry will only happen through a robust overhaul in the way new technologies are accessed and used as well as through innovative ways of ensuring team working through new management approaches. This seems to be consistent with the argument put forward by Christian et al (2012) that, collaboration would add value and bring innovative techniques to organizational supply chains, in this case, to the construction sector.

The absence of early collaborative team work (Modi, 2006) with all relevant disciplines and or persons responsible for a construction project has led to some proven cases of defective construction works (Barrett, 2008) and in some other cases litigation, for instance, Maison D'Or is an empirical evidence which demonstrates how a client successfully instituted litigation cases against his project designer and architects, builder, structural, electrical and mechanical engineers and the overall project manager for a poorly designed, built and totally defective construction (Barrett, 2008). Another of such instances was the case between McGlinn v. Waltham Contractors in (2007) bordering on construction procurement (Barrett, 2008).

Contextually, the term 'defect' has also attracted paradox meanings as demonstrated in some legal cases, such as, Tate v. Latham & Son case of (1897) where defect was defined as 'a lack or absence of something essential to completeness'; also in Yarmouth v. France (1897) defect was defined as 'anything that renders the item or plant etc. unfit for use for which it is intended, when used in a reasonable way and with care' (Barrett, 2008). Conversely, in the case of Jackson v. Mumford (1902), it was decided that the term did not include 'a design defect' (Barrett, 2008). It is apparent that there have been quite a number of paradoxical and legally interpreted technical meanings of 'defect'. However, for the purpose of construction and building industry, defect succinctly put means, anything which does not conform to an agreed specification (Barrett, 2008). It could therefore be implied that, a defective construction project could potentially become unsustainable.

Therefore, attempt to build a place of refuge, possibly devoid of any possible defect(s) is innate in humans. Arguably, humans sort for better buildings or places of refuge in response to changes in their physical environmental typography over time. Basically, buildings are an integral part of sustainable development and a sustainable building could only be achieved through sustainable construction, communities and technologies (Conte and Monno, 2001). Accordingly, many definitions have been advanced by scholars on sustainable construction, Kibert et al (2000) and Maiellaro (2001) opined therefore that, sustainable construction is basically the 'creation and responsible maintenance of a healthy built environment based on resource efficiency and ecological principles’.

This definition sounds too simplistic, broad and technically weak. In the first place, it does not pay attention to technical elements like, variations in typography, probably caused by impact of climate change and other related environmental elements with relations to their roles in achieving sustainable construction. It also failed to highlight the need for usage of renewable and or recycled materials to construct the buildings like suggested by European Community for managing sustainability in construction (Zachmann, 2000) and Maiellaro, (2001). Due to the lack of consensus on the definition of sustainable construction, a pragmatic approach was taken through an International convocation of a conference by 14 countries which arrived at a seemingly applicable definition for sustainable construction construct, and their conclusions was underpinned by divergent national points of views emanating from various countries (Maiellaro, 2001). The framework upon which their report was based reflected questions such as;

- What kind of building would be built in 2010 and how will we adopt existing buildings?
- How will we design and construct them?
- What kind of materials, services, and components will we use then?
- What kind of skills and standards will be required?
- What kind of cities as settlements will we have in 2010?

A key drawback of the (W82 CIB report, 1998; Maiellaro 2001) conference is that, the authors did not conclude on any definition, perhaps because of the fact that, an attempt to do so will only polarize countries against each other. Rather, the conference only succeeded in outlining what should be best described as parameter framework upon which respective countries could key into whilst developing their indicators to gauging whether or not a building is sustainably constructed or not, therefore, was not quite successful as it were.

Also, drawing inference from the definition of sustainability adopted by the United Nations Commission on Environment and Development (see WCED, 1987), this is frequently used, Tanker and Burt (2004) and Hermreck, (2012) concluded that, sustainable construction is the use of materials, techniques and or methods to construct and maintain a structure and or building which meets present needs without necessarily or obviously endangering and or compromising the ability of posterity or future generations from accessing materials to meet their own needs. This definition of sustainable construction apparently makes more application sense and relevant to that earlier given by (Kibert et al 2000; Maiellaro 2001). Therefore should be adopted for the purpose of this research thesis.

Furthermore and in an attempt to put the discussion into context, Calkins (2009); described the site materials needed to achieve a sustainable construction as, materials which basically minimize resource use which reflect low ecological impacts, and mitigates or completely eliminates human and or environmental health risks to achieve a green and sustainable building. This means that, any building construction which does not demonstrate the use of these material elements, in terms of site materials, would not be so referred to as sustainable construction.

Consequently, all sustainable construction must endeavour to use such materials and or products that would mitigate environmental impacts, such as; Certified wood, Minimally processed materials (uncut stones and bamboos), Specified low embodied energy materials, materials produced with energy from renewable sources and local materials (Calkins, 2009). Other materials for sustainable construction that could mitigate or totally eliminate human health risks would be; Products and materials with low-emitting capacities and products and or materials that avoids Toxic Chemicals or By-products (Calkins, 2009). Furthermore, site construction manager along with other different disciplines involved with sustainable project should ensure that the design architect is not left out in the quest to achieve a sustainable construction. Calkins (2009) suggested possible products that could assist with sustainable site designs strategies, such as; Promoting s site's Hydrologic Health (like factor natural drainages into site designs and mitigate impermeable surfaces), products that Sequester Carbon (like lumber and bio-based products), design products that have the capacity to mitigate Urban Heat Island Effect. It could be argued that, Calkin's suggested sustainable site materials and designs has brought the argument on sustainable construction into proper perspective, although his suggestions may not be universally acclaimed, but they have made it a lot easier to potentially measure or gauge sustainable construction using the above framework parameters.

2.14. Benefits of Sustainable Construction

Generally speaking, sustainable construction, despite all the criticisms, currently attracts, and will continuously attract a variety of benefits across the socio-economic and environmental divides of human activities. Though the full benefits might not be immediately seen, it is clear that, a critical beneficiary of sustainable construction, in the long run, is the future generation, if the current generation uses resources reasonably. This fact resonates and is fully captured in the second part of the United Nations Commission on Environment and Development (see WCED, 1987) definition of sustainability, which is "….. without compromising, endangering or eliminating the ability of future posterity to meet theirs", thus, a key benefit of any sustainable construction would be in view of not endangering and or eliminating the ability of posterity to meet their own, economic, social, environmental, technological, ecological and other related human needs.

Furthermore, it could also be inferred from other commentators who streamed their definition of sustainable construction from the United Nations Commission on Environment's (1987) definition that, if the right materials and methods are used to construct and maintain a building or structure without knowingly eliminating or endangering the chances of future generations to access necessary materials and methods to meet their own needs, then sustainable construction has taken place (Tanker and Burt, 2004; Hermreck 2012) and the future generation will invariably benefit from such responsible act. Succinctly put therefore, there must be the act of deliberate resource conservation on the part of the current generation (Hulse, 2007) which will arguably, in the short term, benefit this generation, but most certainly will benefit the future generation, in the long run.

Also, other direct benefits of sustainable construction cuts across reduction of waste, enhanced productivity and learning, reduction in operating cost and overall reduction in liability to all stakeholders (Halliday, 2008). For instance, operating cost could be reduced by as much as 30% if all stakeholders follow prescribed regulations on the best and most sustainable ways to access materials for construction and, on the other hand, there will be a visible reduction in the amount of solid waste generated on every construction site which will be of enormous environmental benefit to humans and it will also facilitate recycling (Halliday, 2008).

Another commentator acknowledged the overall benefits of sustainable construction, but cautioned that such benefits need to be adequately managed, because, sustainably designed buildings or construction can still be unsustainable, if adequate steps are not taken to manage it (National Audit Office, 2007). Although these direct benefits cannot be quantifiably measured, the suggestion is that the sustainability should be adopted as key aspect of professional practices and therefore ensure the early integration of facility management team through adequate education, thus over time it would become apparently visible and perhaps measurable to all stakeholders (National Audit Office, 2007; p.14) in terms of new knowledge gained.

Yet again, another government regulatory department believes that, sustainable construction stands to potentially benefit the society economically, environmentally and socially as well as ecologically (DOE, 2003). Underpinned by these potentially realizable benefits therefore, both in the short and long run, some governments are seen to be encouraging most construction designers and firms to implement sustainable construction thus, leading to a huge demand for sustainable construction professionals with proven practical and educational pedigree in sustainable construction and management (DOE, 2003) which leads to sustainable projects. This has further influenced higher educational institutions in Singapore and the United States of America to introduce construction and, indeed sustainable construction into their main stream educational curricula (Ofori, 1990; Rusk and Bhattacharjee et al.

2012). Thus, this approach leads to a clear and immediate educational benefit to the society and communities through the introduction of new knowledge frontiers.

However, and in a twist to the benefits of sustainable construction, another scholar on the subject posed the question of, at what point can the benefits of sustainable construction be felt or rather, whether sustainable construction should be considered at global, national and or local levels, using either global and or local indicators (Asiedu and Scheublin et al. 2007). They finally concluded that, local indicators should be developed and used to measure sustainable construction because of inherent national (local) peculiarities. These local indicators should be further linked to other similar localities, perhaps with same climatic peculiarities, and then extended nationally and finally globally through comparative benchmarking for possible improvements (Asiedu and Scheublin et al., 2007). In other words, it is not reasonable to use one international indicator to arrive at the potential benefits of sustainable construction.

This point is rather quite interesting because, a lot of other socio-political, environmental and economical phenomena have unfortunately been judged based on one global parameter which, in the first place, lacks a reflective demonstration of all peculiarities in local and global communities represented. Often times the developing world are the worst for it. Therefore, there should be localization of benefits and performance indicators across all social strata, but underpinned by a strong intra-societal, inter-local, inter- regional and international comparative benchmarking mechanism to establish acceptable best practices (Asiedu and Scheublin et al. 2007) driven by local peculiarities.

In an attempt to deconstruct any suggestion of present or future potential benefits to sustainable construction, Kunstler and Salingaro (2001) in their article, “the end of tall buildings”, opined that, the race to construct skyscrapers by ambitious clients and project managers, have always and will continually endanger the complete shift in the current building culture to a sustainable one that could potentially guarantee benefits from sustainable construction. Although this point has generated lots of debates as to whether or not we need skyscrapers, these commentators have argued that the end of skyscrapers was near, if we are to make any sense of sustainable construction (Kunstler and Salingaro, 2001).

They concluded that, the desire for skyscrapers across the world makes a mockery and contradicts the concept of sustainability and sustainable construction because, sustainable construction specifically demands that all sustainable projects must meet both economic, environmental, social, recycling and safe and responsible disposal of construction materials with mitigated impact risks on the environment and humans now and in the future (Kunstler and Salingaro, 2001). Within the context of sustainability therefore, this does not seem to be the case, based on the drive to construct skyscrapers (especially in the Western world) because of the cost and health risks and other unquantifiable dangers they pose to both humans and the environment.

Thus, the culture of skyscrapers will impede or eliminate any gains of sustainable construction, except this is strategically and gradually brought to an end. Furthermore, pro-skyscrapers commentators, seem to view the concept of sustainability from a rather partial angle because, their position is completely at variance with Halliday, (2008; p.73-74) who argued that sustainable construction should visibly reduce the amount of solid waste materials generated on every construction site which will benefit humans and the environment as well as facilitate recycling and also reduce operating cost by as much as 30%. Unfortunately, this cannot be categorically said of skyscrapers.

2.15. Main Findings from the Literature Review

This literature review identifies significant issues facing the UK construction sector. The key findings are presented under the following:

- Supply chain
- Innovation
- Sustainability

Supply chain

The literature review establishes that the construction sector has a lack of understanding of innovative supply chain concepts and practices. A number of critical success factors are identified which could contribute towards the construction industry supply chain.

- The trust and motivation among organisations and the people in them;
- leadership;
- Organisational and individual capabilities for knowledge transferring and sharing such as; observational capability, absorptive capability, application capability, dissemination capability, conversational capability and routing capability;
- Business strategies aligned to share and transfer knowledge in the construction industry supply chain;
- Mechanisms used for identification of product/process improvement opportunities;
- Reception to identification of types of supply chain innovative knowledge to transfer and share reception to identification of supply chain innovative knowledge source and recipient.

Also, the postulations in most of the journals reviewed attested to the fact that, achieving supply chain innovation will only be made possible through IT innovations, collaborative interchange amongst different supply chain and construction teams, early involvement of the supplier in the design stages of any construction work as well as research and development.

Innovation

A key finding suggests a lack of integration and collaboration in the supply chain. The review confirms that innovative practices/processes require collaborative environment for both internal functions within an organisation as well as with the external organisations. That is, an effective communication and resource sharing strategy in the supply chain can enhance the innovative products/ processes to generate greater business value.

Also, there are significant problems with the building products suppliers' project-based organisations. The main causes of the problem being inefficient communication in the innovative processes.

The reason for the inefficient implementation of innovative practices is because thousands of small and medium enterprises are involved in supply chain (BIS, 2011, 2013). In most cases, these enterprises do not have any prior relationship or trust between suppliers-customers links. Overall for the industry the following observations were noted:

- Lack of understanding and awareness of the importance of products/processes
- Absence of trust and motivation among the organisations in the supply chain

- Short term supply chain relationships among suppliers and sub-contractors
- Traditional ways of working and lack of reception to new innovative ideas
- Fragmented nature of the construction industry

Sustainability

Despite the conflicting definitions and description of sustainability and sustainable development as well as what could possibly constitute sustainable construction, scholars and international agencies have been able to arrive at seemingly acceptable definitions and have therefore progressed at looking at key elements and development of local and international indicators.

It is clear that, if governments and all stakeholders collaborate, early enough, appropriate benefits could actually materialize and be sustained for this generation and, lay the foundation of bequeathing a sustainable world where future posterity will not be endangered and or hindered from accessing social-economic, environmental and ecological necessities that would enable them meet their everyday needs.

2.16. Key Emerging Themes from the Literature Review

The Table 2.3 below captures the emerging themes from the literature review.

Key emerging themes	References
Key elements of innovative practices and/or processes • Innovative supply chain practices • Innovative product design practices • Lean application and adoption in design and product / materials development process • Innovative products production / operations practices	Pero et al. (2017); Von Hippel E., (1988); Adeyeye, K. et al. (2007); Beamon (1999); Banerjee (2001); Seuring and Muller (2008);Rao (2002); Carter and Carter (1998); Ofori (2000); Egbu, C.O., (2005); Theyel (2000); Zhu et al. (2005); Hosseini (2007); Handfield et al. (2002); Montabon et al. (2007); Atkinson, G. (2008); Talbot (2005); Drumwright (1994); Nagel (2003); Walker and Brammer (2009); ElTayeb (2011); Kleindorfer et al. (2005); Bansal and Roth (2000); Min and Galle (2001); Benito and Benito (2008); Lee et al. (2012); Van Hoek (1999); Zhu and Sarkis (2006); Delmas and Toffel (2004); Lynagh, C., (2011); Lamming and Hampson (1996); Lin et al. (2001); Sroufe (2003a); Gungor and Gupta (1999); Shrivastava (2007); Kjaerheim (2004); Helmes and Hervani (2006); Shang et al. (2010); Chen and Monahan (2010); Azzone and Noci
Key parameters, drivers and barriers in adopting innovative supply chain processes and/or practices • Main drivers behind innovative supply chain • Main barriers to innovative supply chain practices for your organisation	
Impact on supply chain innovations • Impact of economic environment on Product innovation practices • Impact of organisational processes on Product innovation practices • Influence of the customers on the organisational culture	

Management practices and organisational performances that have contributed to the UK Construction Industry within the last 10 years • Innovative supply chain management practices • Innovative marketing • Performance measure - influence of Innovative supply chain practices on the following firm performance parameters • Innovative supply chain logistics practices • Use of semi-automated construction equipment for supply chain processes • Lean thinking in supply chain for construction project management • Lean Production and planning in supply chain for construction projects in our company	(1998); Hu and Hsu (2006); Pil and Rothenberg (2003); Hanna and Newman (1995); Hansman, R. (2010); Bribian, I.Z. et al. (2011); King and Lenox (2001); Murphy et al. (1996); Brennan, M. and Cotgrave, A.J. (2013); Berry and Rondinelli (1998); Corbett and Classen (2006); Berger at al. (2001); Lee (2009); Walton et al. (1998); Edwards, B. (2002); Beamon, B M (2008); Wu and Dunn (1995); Franzoni, E. (2011); Aragon-Correa (1998); Melnyk et al. (2003); Pun et al. (2002); Holt and Gobadian (2009); Green et al. (1996); Ferguson and Totay (2006); Hervani et al. (2010); Hall (2001); Li et al., 2006; Preuss (2007)

Table 2.2 The emerging themes from the literature review

The identification of the key themes, both the drivers and the barriers, for the innovative supply chain practices are necessary for effective progress. However, it can be overwhelming for manufacturing SMEs to address all barriers identified in the literature review and some may even consider it as a poor application of available resources (Tinsley and Pillai, 2006).

The cost of financing a business venture, competitive challenges, regulatory pressure, poor information sharing and technical knowledge can create barriers in adopting innovative supply chain practices (Post and Altman (1994); the employee attitude, poor senior management, inadequate communication and traditional practices could create obstacles to strategic growth performance.

Based on the barriers and drivers identified, as well as the noted observations above, a theoretical framework has been developed (see Figure 2.7 below), to guide this research study for the construction industry supply chain product manufacturers. It is hoped that this will serve to inform the development of the conceptual framework required in academia to enhance our knowledge and understanding of the issues and factors that impact the sustainability of the construction industry. Furthermore, to help policy makers to make improved response to policy relevant issues in the supply chain of the UK construction industry.

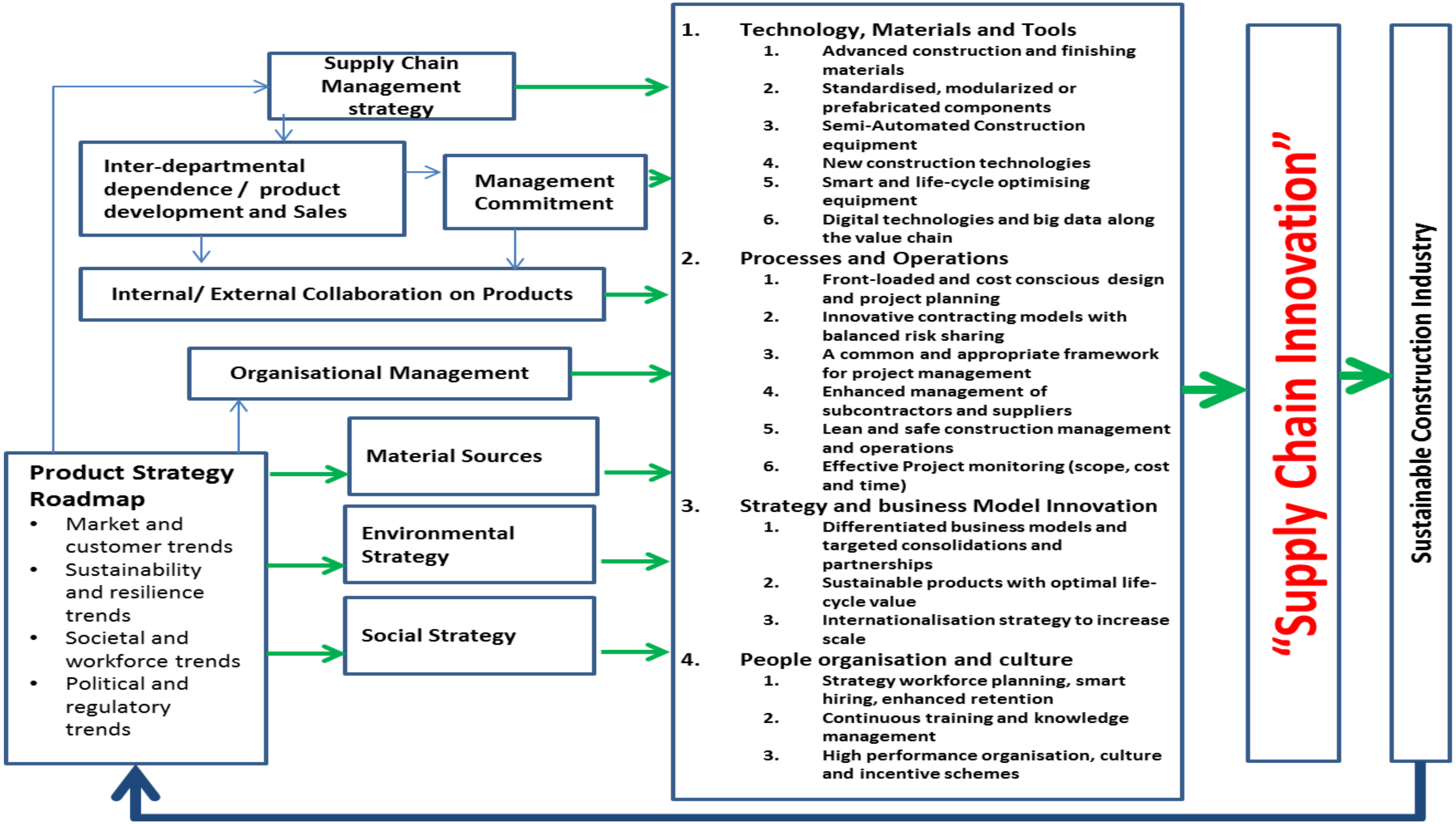


Figure 2.7 Emerging areas of research study for the UK construction industry sustainability

2.17. Summary

This literature review has highlighted the themes associated with innovative practices for the products and materials manufacturers in construction supply chains. The review establishes that the construction sector has a lack of understanding of innovative supply chain concepts.

Ten key sub-themes are identified as the main drivers of this research thesis. These sub-themes or sections with the relevant authorities include:

- **New product development** - PDMA (2003), Blischke and Murthy (2000), Ulrich and Eppinger (2011), Baxter and Gao (2005), Johnson et al (2001) - were some of the authors examined.
- **Product innovation** - Hsu and Fang (2009), Cooper (1999), Balachandra and Friar (1997), Tucker (2001), OECD (2005), Trott (2005), Ettlie (2006), Bessant and Tidd (2007), Salunke et al. (2011), Goodridge et al. (2012), Keeley et al. (2013), Coad et al. (2014), Coad et al. (2014), Wheelwright and Clark (1992), Annacchino (2006) Boer and During (2000), Katayama and Bennett (1999), Shah and Ward (2003), Wilson (2010), Enkel et al., 2011) - were considered for this studies.
- **Lean production practices** - Krafcik (1988), Womack et al. (1991), Womack and Jones (2005), Browning (2003), Karlsson and Ahlstrom (1996), Khan et al. (2011), Ward et al (1995), Sobek at al. (1999), Morgan and Liker (2006), Alam et al. (2010), Gunasekaran (2001), Xiaoli and Hong (2004), Wang and Koh (2010), Meybodi (2003), Anderson (2004), Feitzinger and Lee (1997), Nakashima et al. (1995), Imai (1986), Fox (1994), Saini (2015), Blecker and Kaluza (2003) and Gardner (2009) – were examined and studied.
- **Perspectives of supply chain** - Teuteberg and Wittstruck (2010), Farmer (1972), Delfmann and Koster (2005), Cousin, D. P. et al. (2006), Kelvin et al. (2006), Kraljic (1983), Womack et al (1990), Lamming (1993), Rich et al (1997), Trent (2008) and Wisner, 2009 – were studied for this research.

- **Supply chain management** – Stevens (1989), Awasthi and Grzybowska (2014), Cholette and Venkat (2009), Cousin et al (2006), Oliver and Webber (1992), Heikkila (2002), Frazier (1999), Delfmann and Koster (2005), Kelvin et al (2006), Cousin et al. (2006), Storey et al. (2006), Burgess et al. (2006), Pfohl (2000), Delfmann and Koster (2005), Cousin et al. (2006), Pualraj and Chen (2004), Croom et al. (2000), Burgess et al (2006), and Croom et al. (2000) – were some of the authors referred and examined for this study.
- **Supply chain innovation** – Trent (2008), Fisher (1997), Tan et al. (2011), Shapiro (2009), Christian et al. (2012), Williamson's (1985), Christian et al (2012), Kanter (1994), Christian et al (2012), Jorde and Teece (1989), Modi (2006), Gerwin and Barrowman (2002), Burt and Soukup (1985), Clark and Fujimoto (1991), Modi (2006), Bonaccorsi and Lipparini (1994), Turnbull et al. (1992), Wasti and Liker (1999), Eisenhardt and Tabrizi (1995), Vickery (2011), Flynn, et al (2011), Barratt and Oliviera (2001) – were some of the authors considered.
- **Research and development** - Bosworth et al. (1993), Frattini and Cheisa (2009), Bayus (1998), Berger et al. (1998), Rashkin (2007) – were some of the authors studied
- **Sustainability** – Williamson et al. (2010), Elkington (1998), Cater and Rogers (2008), Michael Blowfield (2013), Morana (2013), Carter and Rogers (2008), Smith (2002), Bossel (2000), Tladi (2007), Stands (2000) and Gechev (2005) – were examined for this research.
- **Sustainable construction** - Mather and Cornick (1999), Rojas (2008), Ofori (1990), Rusk and Bhattacharjee et al. (2012), Ofori (1993), Christian et al. (2012), Cornick (1996), Christian et al (2012), Barrett (2008), Conte and Monno (2001), Kibert et al (2000), Zachmann (2000), Maiellaro (2001), Tanker and Burt (2004) Hermreck (2012), Kibert et al (2000), Calkins (2009) were considered for research.
- **Benefits of sustainable construction to the environment** - Tanker and Burt (2004), Hulse (2007), Halliday (2008), Ofori (1990), Rusk and Bhattacharjee et al. (2012), Asiedu and Scheublin et al. (2007), Kunstler and Salingaro (2001) and

Halliday (2008). The Table 2.3, captures the emerging themes from the Literature review. The identification of the key themes – both the drivers and the barriers – for the innovative supply chain practices are necessary.

It was also observed that achieving supply chain innovation will only be made possible through IT innovations, collaborative interchange amongst different supply chain and construction teams, early involvement of the supplier in the design stages of any construction work as well as research and development. Furthermore, despite the conflicting definitions and description of sustainability and sustainable development as well as what could possibly constitute sustainable construction, scholars and international agencies have been able to arrive at seemingly acceptable definitions and have therefore progressed at looking at key elements and development of local and international indicators.

Finally, the benefits of sustainable construction were not left out of the conceptual contradictions and complexities. However, it is clear that, if governments and all stakeholders collaborate, early enough, these benefits could actually materialize and be sustained for this generation and, lay the foundation of bequeathing a sustainable world where future posterity will not be endangered and or hindered from accessing social-economic, environmental and ecological necessities that would enable them meet their everyday needs.

Chapter Three
Context of the Research

3.1. Introduction

This chapter is extension of the literature review from chapter two and specifically focuses on the research context.

This research study is aimed at critically analysing all supply chain processes and understanding how innovations drive and or deliver sustainability in the UK construction industry. In the main, effective and efficient supply chain is crucially important for the UK construction industry.

Therefore, this chapter articulates the contextualised motivation and rationale for the research project in the sections relating to the subject being studied – the nature of supply chain innovation for the sustainability of the UK construction industry.

3.2. Trends Driving Sustainable Construction Globally

Before concentrating on in-depth study of the UK construction industry a brief snapshot of the trends for the sustainable construction is provided.

According to the Urbanization Megatrend report (2016 ITA Building Products and Sustainable Construction Top Markets Report/6) more than half of the world's population live in urban areas, and nearly all countries across the globe are experiencing increasing urbanization. This urbanization trend across the globe is continuing to drive demand for new buildings as well as reconstruction and retrofitting of existing buildings, as local government authorities toil to create settings in which highly dense population areas can continue to prosper. This demand on building infrastructure also fuels a responsibility to build more sustainable buildings that are environmentally acceptable, conserve energy, water and other resources while supporting occupants' safety, health and productivity and adding to the flexibility of the built environment.

The trend of innovating sustainable construction supply chain across the globe and diverse markets settings is driven by government policies, customer preferences as well as choices and market forces. This growth trend includes both developed and developing world markets and is not limited to any one specific regions of the world. In some ways, this demand for sustainable building infrastructure creates strong opportunities for UK suppliers of construction products such as heating, ventilation, air conditioning and refrigeration (HVACR), lighting, plumbing products, wood products, insulation, windows and doors and glass.

Some of the UK manufacturers of these product groups already have excellent reputations for product reliability, variety, quantity and quality.

In some parts of the world, the public-private partnerships regularly follow practices of sustainable construction under some specific aim goals or objectives. Therefore, the relevant policies and market growths associated with the construction industry supply chain sustainability objectives and specific initiatives are increasing across the globe and subsequently creating opportunities for building product manufacturers.

- **Water efficiency:** this efficiency drive goes hand in hand with energy efficiency drive; across the globe water shortages and frequent draught conditions highlights the importance of buildings in creating more sustainable environments. Some consider that 20% of total fresh water use is in buildings and there is considerable opportunity to make a difference. Across the globe major building construction projects, motivated by consumer demands, are seeking new buildings with water conservation processes and management strategies. Some examples include use of water-efficient fixtures and appliances to separation of un-contaminated natural-water for re-use, to rainwater collecting and storm water management. In short, improved water efficiency can also provide simultaneous energy efficiency gains.
- **Energy efficiency:** there is essentially, a global drive to continue to increase gains from current sources. Some estimate as much as over 30% of the world’s energy use is considered to be taking place inside buildings. In short, the increasing building energy efficiency continues to exercise major influence on energy demand

and greenhouse gas (GHG) emissions; where, the products are expected to have the ability to make strong inputs to increasingly energy efficient building performance.

- **Resilience:** Resilience as a notion has been receiving significant attention from the international governments, banks and investors, international development organizations and private sector construction investors. Faced with both natural and man-made risks, the ability to sidestep or endure or survive and recover from influences of natural hazards is essential to economic and social strength. In the UK, buildings have a clear role to play in this domain by creating opportunities for the UK building product exporters. The energy efficient buildings are able to operate for longer without external power sources and require less power at full operational levels. Buildings with high quality windows and doors, glass, insulation, wood products; and ventilation systems create safer, more comfortable environments in the case of an impact, extending reliability of operations. Water conservation and management via plumbing products likewise create less demand on external systems and extend a building's operational life in the event of an external impact.
- **Net-Zero Energy Buildings (NZEB):** The concept has continued to occupy thoughts globally. The government policies and private enterprises are seen as being prepared to designing, building and operating structures in which the total amount of energy used by the building on an annual basis is approximately equal to the amount of renewable energy generated on the premises. Since it is known that achieving high energy and water efficiency within the building is required to minimize demand for energy, it is important to this model. As a result, in the UK for the construction industry supply chain there is an opportunity for new products and innovation.
- **Intelligent buildings:** An intelligent or a smart building is normally recognised as one echoing a universal approach to a building's design, construction and its subsequent operation to maximize efficiencies, residents comfort and other practical priorities. At the core, the constructed building is a network of multi-

systems which communicate within the building and externally to optimize performance. Intelligent buildings create direct opportunity for design services and information and communication technologies solutions; and create demand for superior building products with integral efficiency and interoperable functions which are compatible with intelligent building design.

- **Smart cities:** Smart or intelligent buildings are recognized key elements of smart cities; some sub-sector building product categories are singled out as essential to intelligent city performance. In the UK, an example includes smart LED Street and infrastructure lighting. Smart exterior lighting is promoted globally for its contributions to energy efficiency, reduced maintenance requirements, public safety and overall usability of the built environment.
- **Healthy buildings***:* Within different building categories, in particular, among institutional and commercial buildings, there is a focus on increasing building value through a healthy building methodology. This places an added emphasis on quality of indoor air, use of innovative and less toxic materials, resident's thermal comfort and access to natural light, safe and efficient water use, and materials and system resistance to contamination. Therefore, in short, all product categories within the building products sector have roles to play in the construction and operation of healthy buildings.

3.3. Area of Study and an Overview of the United Kingdom

The island nations of the UK include England, Scotland, Northern Ireland and Wales (Crahan and Kreiger, 2001); and located off the north-western coast of continental Europe (OECD, 2013). Statistics also shows that the United Kingdom occupies the most extensive part of the British Isles archipelago which covers Island of Great Britain and the north-eastern one-sixth of the Island of Ireland including other smaller Islands (OECD, 2013). Arguably, it is believed that climate change and tectonics played critical parts in the geomorphology formation of the United Kingdom's landscapes (Warburton and Evans, 2011). Although some authors like Bryant and Haslett (2007) and as cited in Lim, 2014) disagrees with this notion stressing that the topography and landscape formation in the British Isles were mostly formed as a result of tsunami events. However, a recent work by Cox et al. (2012 as cited in Lim, 2014) using evidence from radiocarbon dating of sub-tidal boring bivalves in cliff-tops deposits in Ireland and other places in Britain, suggest that they were formed as a result of modern storm waves.

Therefore, the evidence from Cox et al. (2012 as cited in Lim, 2014) study could also suggest that more recent storm waves have come to redefine the landscape and topography of modern day Britain. The country lays between the North Atlantic and South Sea (Irish Sea in the west and North Sea in the east), and extends up to 35 km of the north-west of France where the English Channel separates both countries (Maps of World, 2013). The United Kingdom's coastlines spans 7,723 kilometres surrounded by oceans and seas on all sides except Northern Ireland which shares borders with the Republic of Ireland, however the country boasts of a mild temperate climate (Maps of World, 2013).

Furthermore, England with an area size of 130,347 square kilometres is the largest country in the United Kingdom which represents over half of the total area of the entire country (Hermitage and Edward et al. 2007). It is believed in some quarters that the size and population of England perhaps partly explains why it has been the dominant political and economic capital within the United Kingdom for such a long time (Tusan and Barczewski et al. 2015). Scotland on the other hand occupies a modest area of 78, 790 square kilometres whilst Wales has a size of 20, 760 respectively (Fuller, 2005). Northern Ireland covers 14,140 square kilometres making it the smallest country in the union (Slomp, 2011) although some commentators tend to give varying figures on the sizes of these regions like Crahan and Kreiger (2001) however there are no remarkable differences in the figures. The estimated population of the United Kingdom as at July 2015 stood at 64,088,222 (Map of World, 2015) though the number of births occurring in the year to mid-2014 is 1.9% down compared to that seen in the previous year but the net international migration continues to increase at 259,700 people in the year to mid-2014 (ONS, 2015). The implication of this is that despite the fall in child birth there has been a corresponding increase in the number of people coming to work and live in the United Kingdom as shown above. This is further corroborated by Nadin and Colomb et al. (2010) stating that there has been a steady rise in the number of Europeans (especially Eastern Europeans) coming to work and live in Britain in the last 10 years.

Though an increased skilled workforce is considered healthy because of its positive contributions to any economy (Siddiqui, 2011), the unfortunate down side to this, according to Aydin (2013) is that an uncontrolled rise in the population of a country without sufficient economic activities would damage and fuel political instability and social turmoil if deliberate actions are not taken to regulate it (Gingembre, 2013). Hence, the sustained increase witnessed over the years in the overall population figures of the United Kingdom makes the issue of sustainable construction of residential buildings and provision of other critical amenities more germane (Udeaja and Perera et al. 2013). This therefore emphasizes the need for strategic innovations in approaches to supply chain management which plays integral roles in the construction sector and vital to achieving sustainability objectives like the green supply chain management introduced into the Chinese construction industry to achieve sustainability (Dai, 2011).

The United Kingdom is made up of four different regions or countries (as shown in Figure 3.3 below) and is centrally governed from London as the political and economic capital (Moulaert and Ancien, 2013; Haggett, 2002; William, 2010). This political architecture was entrenched during the periods of nation building and formalized by the Acts of Union with Scotland and Ireland in 1707 and 1800 (O'neill, 2014). Instructively and to give other regions in the union what seemingly looked like some sense of inclusiveness and political relevance some legislative and executive powers were devolved to the respective regional assemblies (Norton, 2013; O'neill, 2014). However foreign and defence policies including social security and fiscal matters were reserved for Westminster after the constitutional reforms relating to devolution in 1998 was passed as law (O'neill, 2014; Norton, 2013). Arguably, observations tend to suggest that there have been some unfortunate outcomes resulting from this partial devolution of powers which has encouraged grudges within peripheral parties and triggered stronger insistent on demands for further devolution (Alonso, 2012; O'neill, 2014).

Figure 3.1 Map showing the United Kingdom and also the four regions with their capitals cities (Source: www. http://www.mapsofworld.com/united-kingdom)

Devolution has been a topic of controversy amongst scholars like Samuels and Webley (2015) who argued that devolution has been a mere ploy by England to continue to dominate the union at the expense of other constituent parts who currently lacked true independence therefore advocated for a complete devolution of political and economic powers to these regions: But in the political front, the devolution of powers in Britain has deepened the disagreements within the union therefore failing to unite and effectively integrating the country (O'neill, 2014). Conversely and despite Britain's geographical diversity the citizens are still closer to each other through the practice of common British cultures (William, 2010). Although each region still demonstrates inherent cultural variations often reflected in their food and language like in Scotland

and England (Haggett, 2002; William, 2010). These inherent complexities have come to also define its parliamentary representations and government, with occasional controversies with London from other regions (Haggett, 2002). It has also been observed that irrespective of the various little villages and quiet towns that dots the United Kingdom's country sides (Haggett, 2002), it is a fact that Britain has experienced highly urbanized movements and has remained a metropolitan country for more than a century (Slomp, 2011). It suffices to note that London just like then, and now, has always been a far more dominant city in Britain (Moulaert and Ancien 2013; Tusan and Barczewski et al. 2015).

Therefore, the need to study the various waves of construction development from the traditional to the current new techniques with a focus on achieving complete sustainability in the construction sector across Britain cannot be less germane (Udeaja and Perera et al. 2013). However, what remain unclear across the four regions in Britain are the level of differences in the implementation of various European Union recommended ideas to achieving a sustainable construction sector because (Hogwood, 2013) argues that the identification of nodal points within the United Kingdom's many levels of sustainability are led by Brussels rather than by central government. This means that other regions in Britain, except England, are in tune with implementing European Union sustainability directives than the framework set by the British central government operating from London (Hogwood, 2013; Layard, 2012). This could be potentially dangerous because national coherence is clearly absent which is further reflected in the sustainability achievements made across the country.

For instance, England has partly shown through that it is progressively committed to the delivery of sustainable housing through sustainable sourcing and supply of raw materials needed in the sustainable construction sector (McLeod and Cherrett, 2013). This has partly been influenced by deliberate government policies such as the 2007 'Waste Strategy' of England which were initiated to mandate both public and private stakeholders to deliver sustainable built environment through sustainably sourced raw materials from a sustainability driven supply chain (McLeod and Cherrett, 2013); including the use of incentives and benefits to encourage compliance by stakeholders like the ‘housing and planning delivery grants’ (Gallent, 2008b as cited in Gallent and Baven et al. 2010). Arguably, such incentives has led to the proposal for the potential delivery of over 200,000 sustainable homes including public infrastructures in England by 2010 through the voluntary Code for Sustainable Home scheme (British Parliament House of Commons, 2006), though many commentators opined that it has not gone far enough and the target has not been met (Bell, 2014). However, in Scotland, this is not quite the case because the Scottish government does not follow the construction policies from England (Hogwood, 2013; Layard, 2012) and it operates a different system of building control, governed by the building Act (Malina, 2013). This ensures that the design and construction of buildings are warranted separately by completing a stream of notifications through the building warranty scheme (Malina, 2013). This clearly demonstrates that Scotland believes in the concept of sustainable construction considering another ambition and aspiration for all new buildings to be zero carbon or mitigated carbon to near zero by 2016/17 (Laing, 2013). However, the overall commitment and achievements it has recorded in the sector are less encouraging when the evaluations of the construction or sustainably refurbished buildings are undertaken (Brennan, 2013). A situation arguably occasioned by the complete disjointedness in the whole construction life cycle in Scotland (Malina, 2013; Brennan, 2013).

Furthermore, the non-compliance to sustainability objectives appears to be worse in Wales compared to England and Scotland although it has demonstrated strong interest in the area by establishing ‘Education for Sustainable Development and Global Citizenship (ESDGC) scheme designed to train young and new entrants into the construction industry (CITB, 2010). Surprisingly, Northern Ireland has a rather interesting approach designed to encourage the teaching and practical application of sustainability development principles. Curiously, they have entrenched these sustainability principles into both primary and secondary schools curricula including the provision of relevant resources to schools and teachers to help them deliver on national strategic sustainability objectives (Martin et al. 2014). Arguably, this will pay off in the long run when schools in Northern Ireland starts churning out technical experts with requisite knowledge and practical skills to deliver on sustainable construction in the country (Martin et al. 2014).

However, with critical evaluation one unfortunate implication of these different approaches towards delivering on sustainable development particularly in the construction sector is that it slows down Britain’s speed to successfully achieve a sustainable built environment as a result of different regional government approaches to the phenomenon (Ross, 2013; Green, 2011). Interestingly, Straaten and Spash et al. (2012) debunked this view postulating that, in accordance with the United Nations framework, achieving the changes that sustainable development implies would only be realized through localized and regional approaches which specifically resonate with Local Agenda 21, as formulated in the Rio conference of 1992. According to Ross (2013) one possible way this lopsided trend on sustainable development can be checked and perhaps reversed is for the central government in London to proactively engage and encourage elected representatives from other regions of the country to collectively redesign a new national road-map. Also, other commentators argued that there is the need to make sustainability a central policy thrust like the UK’s ‘Sustainable Development Strategy’ (UK Government, 1994, 1999 as cited in Stallworthy, 2013; Hogwood, 2013).

Growth and problems in the UK construction industry the construction industry has passed through various stages of growth in the United Kingdom of Great Britain for a long time (Thorpe, 2003). Arguably there are seemingly notable similarities between the experiences of the United Kingdom’s construction industry organizations and the four standard growth stage models for the development of data processing within an organization as suggested by Gibson and Nolan (1974 as cited in Thorpe, 2003). They further argued that the United Kingdom’s construction industry has currently entered into the stage four of the four-stage model (Thorpe, 2003). This postulation has however been rejected and debunked by Cooper and Kagioglou et al. (2008) who stressed that the construction industry in the United Kingdom is too large to be stereotyped into four stages of growth. Rather other commentators such as Lewis and Lloyd-Jones (2014) opined that the construction industry development and growth in the United Kingdom has witnessed phases of decline, rebirth and consolidation dictated by advancement in British industrial capitalism and technologies. Also, Ball (2014) suggested that the construction industry, at large, is often best understood based on the complexities underpinning its social relations, historical and overall domination by large scale capitalist enterprises which deliberately ignores and contrasts, specifically, with the interpretations of construction industry which likes to internalize its problems.

Subsequently, Michael Ball (2014) in the same vain argued that, though industrial growth or restructuring are generally vague terminologies because they are often used to describe processes of structural changes within an industry where changes normally transcends introduction of new technologies, capital and labour relations or relocating point of production. However, this contradicts the case in the construction industry, where growth and restructuring of this sector in the last twenty years has been linked closer to owners of capital rather than innovations in methods of production (Ball, 2014). Thus the key element that has determined growth and changes observed within the British construction industry since the 1960s centres on complex and multiple mergers (Ball, 2014). This merger approach has arguably contributed to the relatively small asset base of British construction firms which have partly contributed to their comparative lack of success abroad (Construction News Magazine, November, 1979 as cited in Ball, 2014). On the other hand, outward looking commentators such as Cooper et al. (2010) and Perera and Ashworth (2015) believed that the British construction industry has witnessed very rapid growth because of the complex mix in trade union activities in response to both government and private shifts in approaches. In other words, the internal growth of the profession was partly tied to increasing complexities in commerce and industry which has put the construction sector as one of the fastest growing within the occupational structure of Britain with the employment rate rising from a mere 4 percent at the start of the twentieth century to currently 10 percent after the 2008 recession (Perera and Ashworth, 2015).

Furthermore, though the construction industry may be generally perceived as dirty, dangerous place to work based on the fatalities rate, insecure and noted for poor career prospects for the highly educated employees (Whyte, 2014; Latham, 1994 as cited in Higgs and Ashworth et al. 2013), this is not quite the case with its operations in Britain. The United Kingdom construction industry on the other hand particularly boasts of a long and honourable national and global historical tradition evidenced by its records of achievements, (Higgs and Ashworth et al. 2013). It is instructive though to note that the effect of BREEAM certification usage in built environment of the construction sector for about 20 years including the implementation of other standards and industrial regulations further suggested that the British construction industry was way ahead in contemporary green building designs hence points to a brighter future for sustainable building designs (Shukla and Shukla et al. 2015).

In contrast however, Barlow (1996 as cited in Higgs and Ashworth et al. 2013) and Retik et al. (2012) disagrees and opined that though global recession has affected most construction industries, the British construction industry in particular has gradually taken a back foot amongst global players which is further aggravated by some internal strife such as the self-protectionist behaviours of different groups but has only managed to maintain its balance. Despite this, Freeman (1987 as cited in Higgs and Ashworth et al. 2013) observed that there has been some elements of incremental innovations within the British construction industry but unfortunately their efforts or shock-wave have only been felt within their immediate surroundings. Hence Higgs and Ashworth et al. (2013) suggested that five generic technological changes such as; materials technology, information, biotechnology, energy and space technologies have created new technological systems that have contributed towards the growth of the construction industry.

Following from the above, it is clear that though the British construction industry has come a long way, there are inherent challenges that has arguably stagnated it from growing in recent years (Retik et al. 2012) particularly in the sustainable construction sector (Ahmed and Opoku, 2015). According to Kibert (2007 as cited in Shukla and Shukla et al. 2015) sustainable construction criteria must reflect reduction in resource inputs, reusing resources, recycling of materials, ensuring that the environment is conserved, eradicating toxic materials, economic viability and emphasis on quality.

However, some of its commonest challenges include, but not necessarily limited to the inability of the sector to keep up with clients/customers' requirements, cost associated with sustainability and top management support and time constraint (Ahmed and Opoku, 2015). These challenging elements however are further extended to contractor or consultant organizations around such issues like; management of conflicting business targets, contract requirements, procurement processes including knowledge and skills of employees together makes the full adoption of sustainability principles harder in the United Kingdom irrespective of the gains made so far (Ahmed and Opoku, 2015). Succinctly put therefore, fundamental elements of sustainable construction according to Shukla and Shukla et al. (2015) shown in Figure 3.2 below suggests that there should be a deliberate consciousness for efficient utilization of raw resources, maintenance of environmental harmony and the approach must be holistic.

Figure 3.2 Fundamentals of sustainable Construction (Source: Shukla et al., 2015).

Finally, it is evident that the British construction industry has advanced from the use of crude traditional approaches to modern approaches and designs which consider economics as central to the sustenance of sustainable construction initiatives (Myers, 2013; Ball, 2014; Adamson and Pollington, 2006). Sadly, the inability to maintain sustained growth in this sector has often been caused or truncated by localized internal quagmire including unhealthy competition between surveyors and architects, consultants and contractors and raw material producers and various stages of the supply chain life cycle (Chalmers and Tookey, 2015). Also, the industry's complex interactions with other relevant external environmental stakeholders including lack of innovative ideas that would have attracted the much needed finance and intellectual resources into the Construction Industry Board to trigger new ideas have all adversely affected innovative growth in the sector (Adamson and Pollington, 2006).

3.4. The UK Construction Industry

According to the Office of National Statistics (2014) the UK construction output accounted for about 6.3% of the total GDP in 2013. Additionally, in 2013, the Department of Business and Innovation Skills (BIS) had stated that, since the recession of 2008, the UK construction industry sector had been disproportionately affected. However, this was contradicted by a newspaper article by Allen (2013) that, in 2013, the UK construction output showed the highest growth since 2007.

In 2007, the construction sector had accounted for just fewer than 9% of the UK's Gross Value Added (GVA) but, by 2011, the sector's contribution had decreased to below 7%. By early 2012, the UK construction contracting industry returned to recession for the third time within five years, (BIS 2013a).

Some industry stakeholders (Baldauf & Hubbard 2011; BIS 2011; HM Treasury 2012; Lynagh, 2011) also held the recession responsible for reduction in business opportunities. Additionally, Baldauf & Hubbard (2011) had observed that the main issue in 2011 with the construction industry was currency inflation, the loss of skills and rising international competition for the UK construction industry supply chain.

Some of the industry observers had maintained that the UK construction industry had a small role in the economy at around 7% of GDP (in 2011), yet believed that the UK construction industry was in position to help kick-start the recovering from recession. In 2011, Lynagh (2011) pointed out that output had shrunk to 0.5% quarter-on-quarter, limiting the annual seasonally adjusted growth to 2.8%. In the UK, by November 2013, construction, output had fallen by approximately 4.0% (£395 million) when compared to October 2013 (ONS 2014) figures. However, in attempt to develop a longer term fixture, construction output had increased over 2% when comparing year-on-year figures of November 2012 with November 2013. In seeking to identify alternative growth opportunities, the BIS report, (2013a) had suggests that, in comparison with Europe and other developed countries, the UK construction sector could explore export opportunities within emerging markets such as Brazil, Russia, India and China (BRIC). This was also observation made by Baldauf & Hubbard (2011). The ONS report, (2014), however, had articulated the concern that the UK construction industry supply chain sector has no adequate export capability. The BIS report had further highlighted that "*the UK firms which export generally tend to be larger, have higher absorptive capacity of 'Know How' (Tacit Knowledge) and are more likely to be engaged in research and innovation activities*" (BIS 2013a). From the UK construction supply chain industry, only 6% of small and medium-size companies were exporting (BIS 2013a).

The BMG research group's findings for BIS in 2013 had uncovered the barriers and strategic challenges of exporting for the UK construction industry Supply chain SMEs. The research had highlighted that the total population of UK construction industry supply chain SMEs in 2012 was 907,195. This was at the time, highest number compared to other industries, with an employment size of approximately 12% of the UK workforce in 2012. The UK construction industry had also noted a 1.2% downfall in employment since 2010. Furthermore, the significant observation was that the UK construction industry had 74% family run businesses in 2010; this number had decreased to 72% in 2012. For the UK construction industry, only 2% of the companies were considered as social enterprises in 2012 after a significant decrease of 50% since 2010.

In terms of business capabilities for the UK construction industry supply chain, there was a reduction of 17% in the improvement of new products and services (BIS, 2013b). For the UK construction industry sector the process improvement had remained constant. However, the UK construction industry supply chain SMEs estimated that in 2012 only 64% of companies had aspirations to grow over the next three years, compared to the 78% of construction sector companies that had growth aspirations in 2010.

These growth aspirations for the UK construction industry supply chain players would have required business motivation, intellectual capital growth and corporate strategy to be aligned with the business strategy and it had seen a significant of decrease of around 14% since 2010.

Since the recession set in, a number of the UK construction industry supply chain SMEs had raised concerns about a lack of financial support but the financial lenders and commercial institutions had argued that the investment was available. Additionally, the survey had revealed that 38% of SMEs had failed to meet the lenders' criteria. Additionally, the report had claimed that 68% of SMEs had obtained all the finances they needed in 2012. The report had also contend that a vast amount of support was available to SMEs but only less than 50% of businesses had received the support or advice. Furthermore, about 40% of SMEs in England and Wales were dependent on accountant firms for business growth advice and information, while 15% or less of business had considered advice or information from consultants or business advisors.

The BIS (2013b) report had further suggested that the UK construction industry supply chain SMEs' growth had decreased since 2010, overall business competences was witnessing the worst fall which was continuing.

Pointing to the UK construction industry statistics of 1990's recession, Baldauf & Hubbard (2011) had raised concern and recommended that - the construction skills on all levels and of all disciplines were lost in previous recessions, with large numbers not returning, often through choice. In particular, it has been suggested that the industry did not truly recover from its skills base losses from the recession of the 1990s.

The BIS (2013b) report had further highlighted that the additional reason for skills loss in the UK construction industry supply chain companies was because organisations were pursuing advice and information from alternative place and were avoiding readily available expert advice from the government and designated authorities.

The first report by BIS, (2013a) had highlights that one of the main drivers for long-term growth was increasing export activities. However, the factors and areas of concern in increasing exports were:

- People and Skills' enhancement: The report showed concern that there has been a substantial fall in apprenticeship completions in construction-related industries in the last three years.
- Innovation Capabilities: compared with other industries, construction has a low level of innovation, measured by R&D.
- Access to finance: The evidence shows that construction-contracting SMEs face more difficulties than other SMEs in accessing finance from banks.
- Supply chain development: The sector is characterised by a high level of fragmentation. Construction Supply Chains require contractor's engagement and continuing involvement, strong relations and collaboration with suppliers.

In 2011, the framework agreement (FA) for the UK construction industry supply chain sector had set growth objectives but emphasised that these could only be achieved while sharing expertise when acquiring new skills. Acquiring skills and developing SME's expertise level with key UK construction industry contacts could assist with understanding of the construction sector and influence on business performance. Some industry observers had noted that the real concern within the UK construction industry was that the traditional way of thinking of businesses and the divergence of the industry (Alashwal et al., 2011; Chen & Paulraj, 2004; London & Kenley, 2001).

Since, the UK construction industry supply chain has a large number of privately owned or family owned companies (BIS 2013b) and was thought to be more fragmented in comparison with its major competitors such as in Germany or USA (BIS 2013a).

> It is a fact that our construction industry is more fragmented than in competing countries such as the US and Germany. There is one UK firm in the top ten European contractors and housebuilders, and only two in the top twenty, (Construction 2025)

The study by Forgues et al. (2009) had put forward collaboration as the major factor in reducing the impact of fragmentation. Forgues et al. (2009) proposed three main approaches to encourage collaboration: practices, integrated teams and integrated design process.

Additionally, Jarvenpaa & Keating (2012) Chen & Paulraj (2004), Blake & Croot (2004), Taylor et al. (2012), Taylor and London & Kenley (2001) had exposed concerns within the UK construction industry, such as industry fragmentation, supply chain and procurement issues, Knowledge Management and taxation. The main concern was that of the UK construction industry supply chain fragmentation and the reluctance to adopt innovative products, operations or processes and seeking new markets. In 2011, Alashwal et al. had observed that an industry-level fragmentation occurs when the number of SMEs increase and the number of the larger organisations decrease. Furthermore, Langford and Male, (2001) had pointed out that in this scenarios the SMEs have no major market share and are therefore unable to influence significant outcomes for the industry and incapable of establishing intra-firms networks; and these points of view were also backed (Gonz'alez et al., 1998; Winch, 2010; Garcia, 2005; Vlies and Maas, 2009).

A number of other authors had also stressed that the construction industry requires an integrated approach (Briscoe & Dainty, 2005; Jørgensen & Emmitt, 2008; Vinodh et al., 2009). In 2005, Briscoe & Dainty had said that, "The UK construction industry remains characterised by adversarial practices and dis-jointed relationships between supply chain participants. In the UK construction industry supply chain generally, the construction companies failed to trust the main contractors, who in turn retain an arm's length relationship with sub-contractors and supply chain suppliers. In the UK the construction projects were treated as a series of consecutive and largely separate operations where the individual players had a very little stake in the long-term success of the resulting building or structure and no commitment to it." The reasoning by Briscoe & Dainty, (2005) indicates that for the organisations, integration of processes and products is required to ensure that better value can be delivered to the customers; and previously this view was echoed by Latham in 1994 and Egan in 1998. Overall, this approach involves clients, designers, main contractors and subcontractors working together as a unified team, rather than as an unrelated collection of separate organisations.

A better understanding of an efficient supply chain was one of the essential elements to integrate the fragmented construction sector (BIS, 2013a, Briscoe & Dainty, 2005; Sanderson & Cox, 2008). Briscoe & Dainty (2005) had pointed out some of the construction supply chain issues, such as “construction supply chains had only existed during projects”. Where after project maintenance support was part of the contract, the supply chain can theoretically remain in existence during the life of the project. Furthermore, construction supply chains on larger projects generally involve a number of different SMEs supplying materials, products and a wide range of construction services.

The other problem for the UK construction industry supply chain is the dependence of the construction industry on a disconnected and largely subcontracted workforce. This serves to increase complication within the supply chain and create barriers when seeking integration.

3.5. Highlighted Problems of the UK Construction Industry

Since the early 1990s, there had been a widespread increase in concern relating to 'value for money'. This has been a recurrent theme for the UK construction industry which has a long history of failing to meet the customer expectations. In 1974, the National Economic Development Office (1974) had suggested that nearly one in five customers were dissatisfied with the service they had received from the industry. In 1998, Egan Report had also highlighted growing dissatisfaction and the under performance of the UK construction industry.

One of the recommendations to drive vision for the UK construction industry was that of improving customer capability and procurement. That is, the UK construction industry supply chain (including Government) has an important role to play in transforming the construction industry. How projects come to market has a significant impact on the ability of the UK construction industry supply chain to provide innovative, value for money solutions. Much waste in construction is driven through the approach to risk across the supply chain, (Construction 2025).

The initiatives introduced over the years serve as a reminder and witness of changes to the way the industry has worked. These reviews included in - The Latham Report "Constructing the Team" (1994), The Egan Report "Rethinking Construction" (1998) and The Egan Report, Accelerating Change (2002). These Reports, each encourages the industry to make improvements and address key issues. The Reports also argued that driving efficiency and greater client involvement and collaboration would help the UK construction industry's competitiveness.

3.5.1. The Latham Report "Constructing the Team"

The Latham Report "Constructing the Team" is acknowledged to have made an outstanding contribution to the development of collective methods or collaborations on how the construction projects are delivered within the UK construction Industry (BIS 2013c). In the main, the Latham Report concentrates on the fragmented nature of the UK construction industry supply chain as a major factor contributing to the lack of or weak communication between all supply chain partners in construction industry projects (Kagioglou & Cooper 2012). Additionally, the Latham and Egan reports have identified the needs for improvements in the construction industry in a number of recommendations or factors. One of the factors is the creation, utilisation and effective implementation of processes at a strategic and operational level (Kagioglou & Cooper 2012). Furthermore, Hope (2012) had pointed out that the Latham and Egan reports highlighted that the requirement of outsourcing itself calls for more emphasis on developing the UK supply chain relationships. It can be argued that since the publication of these reports the interest in supply chain management within the construction industry had gained further research interests.

3.5.2. The Egan Report

The Egan Report, which was published in 1998 had highlighted that the main issues within construction sectors were client dissatisfaction and the underachievement of the sector. The report had focused particularly on the scope for improving the quality and efficiency of UK construction industry (Kagioglou & Cooper 2012). Furthermore, the report had presented five key drivers for change (Egan 1998):

- Committed Leadership,
- Being Customer Focused,
- Integrated Processes,
- A Quality Driven approach,
- Commitment to People

The report had further emphasised that the fragmentation of the UK construction industry inhabits performance improvement Egan (1998). Additionally, the report had pointed out that fragmentation in UK construction industry has its strength and weakness. On the positive note, it had provided flexibility to deal with a highly variable workload and on the negative note; the extensive use of sub-contracting had increased and affected adverse contractual relations.

Orange et al. (1994) had emphasised that the construction industry is organisationally complex and highly fragmented with more than 95% of companies being SMEs. Furthermore, the UK construction industry is suffering from the construction industry supply chains fragmentation and relationships that are both dynamic and transient as a direct effect of the temporary nature of construction projects, resulting in an inefficient communication structure between the construction industry supply chain participants.

Likewise, Orange et al. (1994) had considered fragmentation of the UK construction industry supply chain partners as a problem within the industry and had identified it as being a critical barrier to change since it was seen as a major factor in the poor communications between parties working together on construction projects.

In 2002 the Egan Report “Accelerating Change” set out demanding targets for the construction industry and followed the report – “Re-thinking Construction” – four years earlier. The key themes of the second report were:

- By the end of 2004, twenty percent (20%) of construction projects (by Value) to be undertaken by integrated teams.
- To increase supply chains by 50%, by the end of 2007
- To develop and implement strategies to recruit and retain 300,000 qualified people in the industry, by the end of 2006.

Furthermore the report had addressed issues such as:

- People,
- Leadership,
- Supply chains' integration
- Product focus

The UK construction industry stakeholders had argued that after almost two decades since the Latham and Egan reports had emphasised such issues to-date the UK construction Industry and its supply chain had not seen much improvements.

It is to be noted that Egan (1998) had discussed and suggested collaboration in construction supply chains but on a series of projects as a long-term relationship tool. However, Briscoe and Dainty (2005) had by referring to some specific real-world examples, had argued that establishing long-term supply chain relationships do not generally work in the construction industry. The collaboration in the construction industry supply chain requires core success factors trust or belief, shared vision or aspirations and longer-term commitments, which serves to motivate the contracting parties to change confrontational relationships to a more cooperative, team-based approach (Taylor et al., 2012).

3.5.3. The Wolstenholme Review

The Wolstenholme Review (2008), report titled, 'Never Waste a Good Crisis' had concluded that the construction industry had made a little progress against the Latham (1993, 1994) and Egan (1998 and 2002) targets and identified a range of actions needed to drive the performance improvement of the UK construction industry and in particular supply chain.

In the main, this report's themes such as the construction business model, capability and delivery were highly significant to the supply chain agenda (BIS 2013c).

A report by Construction Industrial Strategy in 2013 had revealed that the results from supply chain interviews confirmed that the implementation of recommendations from the Egan and Latham reports has had an impact on behaviour within the UK construction industry supply chain. However, it is not clear which customers and to what extent the UK construction industry supply chain partners, had benefited from the results of the reports by Egan and Latham.

In fact, some industry observers had noted that the construction industry was becoming more fragmented, adversarial and less integrated because of the then downturn (BIS 2013c).

This report had identified a series of actions that should be taken jointly by the Government and the industry to harness the potential of the UK construction industry supply chain to improve performance and productivity. The recommended actions were:

- Promoting an agenda of change at all levels of the supply chain
- Developing the quality and capability of site management staff to drive performance improvement through supply chain interaction
- Better alignment of the construction industry in the supply chain, in procurement and in risk transfer practice
- Encourage procurement practice for the early engagement of sub-contractors
- Capability development throughout the supply chain
- Developing an emphasis on the supply chain in cost-led procurement
- Promotion of effective practice for change management

- Promotion of awareness of all sources of waste in construction industry, not just physical waste
- Development of a commercial exchange model recognising that small businesses are a fundamental part of the UK construction industry.

When viewing all the reports since the 1990s, the Egan, Latham, Wolstenholme and BIS reports all underline the UK construction industry supply chain development. The key indicators put forward were:

- Integrating teams
- Integrating processes
- Promoting quality
- Capability development
- Skills' development.

It is to be noted that some other scholars had also put forward some other views on developing the UK construction industry supply chain and therefore, reducing the impact of fragmentation.

Furthermore, Alashwal et al. (2011) and Hope (2012) had presented comparable opinions and suggested several factors which may reduce the negative impact of fragmentation and hence facilitate knowledge sharing and transfer. These factors were:

- Good knowledge management
- Encouraging partnering
- Utilising design and build contracting methods

However, the question raised by Orange et al. (1994) articulates who will be taking the ownership of knowledge creation and who will be having access. As previously stated the major difficulty within the construction industry is the fragmented nature whereby companies only have a relationship with the sub-contractors during the delivery or execution of the project.

It is clear the investigations of the UK construction industry supply chain through a number of reports, recommends stronger customers and partners to build trust; and relationships at the early stage of a project and during the project (Brewer & Johnson, 2004), Briscoe and Dainty (2005). Vrijhoef & Koskela (2000) had also suggested the need for having and building trust between the trading partners.

Warren & Rhodes (2006) had used the example of car manufacturing and how the automotive industry manufacturers had developed trust and relationships with the suppliers and achieved success in a particular manufacturing setting.

However, some industry stakeholders continue to argue that the automotive industry allows for building of longer term relationships but it is hard to develop longer term partnerships when the relationships are temporary and based on project by projects.

In majority of the cases, the UK construction industry supply chain partners work on a project basis with the outcome being that it is hard to maintain trust and relationships with supply chain partners or subcontractors after the completion of the project.

3.6. Construction Industry Supply Chain

According to Walker and Alber (1999), the theory of the 'supply chain' is commonly acknowledged as the flow of information, physical distribution, and the capital used to deliver products and services from raw materials to the customers. Furthermore, Gunasekaran and Ngai (2004) had stated that the supply chain management (SCM) is a 21st century global operation strategy for achieving organisational competitiveness. The first known supply chain model was credited to Forrester (1961) and was initiated by the Toyota Production System (TPS) to reduce the inventory with the Just-in-Time (JIT) methods. The supply chain management started to gain prominence in mid 1980s after Houlihan (1984) had introduced supply chain management as theory in the logistics sector (Lamming, 1996).

However, New, (1997) has argued that over a decade and half, the supply chain management, literature has shown a confusion of expressions and explanations, (Dyer et al., 1998; Nassimbeni, 1998; Tan et al., 1998; Ellinger, 2000). Some of these expressions and terminologies include:

- Combined purchasing strategy
- Supplier integration
- Supply based management
- Buyer-supplier partnership
- Supplier alliances
- Supply chain synchronisation
- Network supply chain
- Value added chain
- Logistic integration
- Lean chain approach
- Supply network
- Value stream

However, according to Tan (2001) while most of the expressions points to a particular part of the subject and concentrate on the current suppliers, supply chain management is the most extensively adopted as well as misunderstood terminology.

London and Kenley (2001) had stated that the supply chain management has often been associated with the management of the physical distribution of products from raw materials through manufacturing processes to the 'point of sale' for the end product. Since 1992, Christopher Martin is recognised as one of the pioneers of the logistics and supply chain movement, influenced by the value-chain concept of Porter (1985) and London & Kenley (2001).

Ultimately, the supply chain management's main requirement is to create linkages between the key business functions and business processes internally and intra-company into a well-integrated and valuable business model.

However, researchers such as Koçoğlu et al., (2011) had pointed out that knowledge management plays an important role in developing a collaborative supply chain, and this view was reinforced by other authors too, (Martínez-Olvera, 2008; Rezgui et al., 2011).

Furthermore, according to Lambert and Cooper (2000) the key components of a supply chain were planning and control, product flow and information flow facility structure. The same authors had further pointed out that in a supply chain management process the components such as the workflow activity structure, the organisational structure and the communication and information flow structure rely on management methods, power, the leadership structure, risk, the reward structure, culture, and attitude. That is, the lack of planning and control is considered to further rely on information flow. A lack of adequate knowledge management and information flow in supply chains results in fragmented process and operations (Zhang, 2012).

To meet the requirements of improved construction industry supply chain and customer satisfaction, the organisations in the construction industry supply chain should encourage knowledge sharing (Briscoe & Dainty, 2005; Zhang 2012). It is to be noted that Lall et al., (2004) had pointed out that when considering the sectors such as electronics and automotive or the e-commerce industry, a fragmented supply chain could offer opportunities for SMEs. That is, availability of multiple suppliers presents the construction industry supply chain with flexibility in outsourcing and increased competitiveness among the construction industry supply chain subcontractors. For these authors argue that the fragmentation is not a new phenomenon; nor is outsourcing; these have been present in one form or another since the beginning of the industrial revolution at least.

One example often quoted for arguments in favour of fragmentation is about how the Android market is highly fragmented and growing rapidly; yet it does not challenge market growth, innovation and the expansion of SMEs according to a recent report by PC Magazine (Albanesius, 2013).

According to Lambert and Cooper, (2000), in the construction industry because of having project based organisational relationships and often one-off projects in the supply chain, the disconnected supply chains has challenged the managerial components of supply chains, the integration and partnering between the subcontractors. This approach ultimately, results in short term relationships and a lower level of trust among sub-contractors and contractors on a project basis. Some researchers have suggested decreasing the negative impact of fragmented supply chains, developing a productive information system (Caballero et al., 2012).

In the main, authors such as Caballero et al. (2012) have all argued that construction industry supply chain integration as well as collaboration requires excellent communication between organisations and efficient knowledge management systems.

In reality, according to Cheng, et al., (2010), the construction industry supply chains are the most complex supply chains, in comparison with other sectors.

For the construction industry the supply chain consists of several different elements such as suppliers, consultants, designers, contractors and other organisations; and these elements have their own supply chains which only join for specific projects durations only.

A typical customer supply chain could include construction firms including, main Contractors, project managers, architects, quantity surveyors, structural engineers, mechanical and electrical engineers, sub-contractors and component manufacturers. Furthermore, the construction projects generally involve many companies supplying materials, components, and a wide range of construction services (Cheng et al., 2010). The Figure 3.3 below is a simplified example of a construction project supply chain given by RICS (2011). In the main, a construction industry supply chain is much complex than is shown in Figure 3.3.

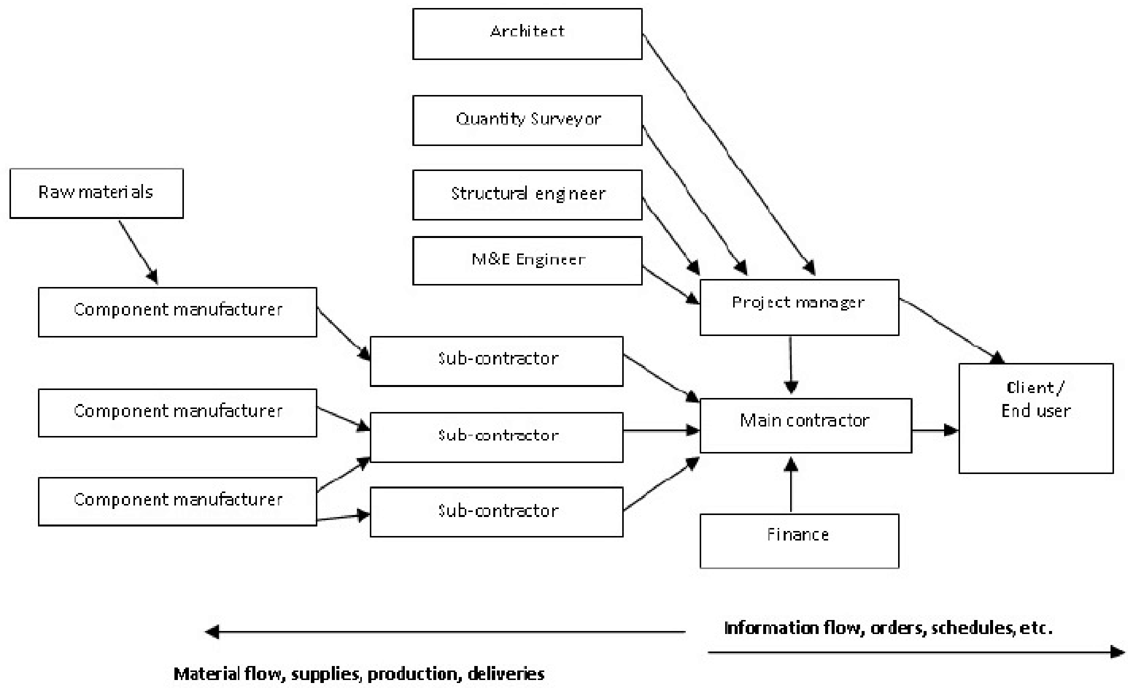


Figure 3.3 The Construction Supply Chain (Source: RICS 2011)

It is to be noted that in the Figure 3.3, the supply chain shows overall three levels, the first level has Information flow, orders and schedules at the project manager, main contractor and finance level who are in communication with the client / end user. The second level, architects, quantity surveyors and engineers communicate with the project managers and the sub-contractors communicate with the main contractors. In the second level, the supply chain manages the flow of supplier's materials, production and deliveries. Significantly, only a one-way communication is shown at all levels of the supply chain.

It can be argued that this one-way communication in supply chains increases fragmentation and results in a supply chain incapable of adding or creating value.

The critical examination of the relevant and related literature on supply chain management and construction industry supply chain has shown that the construction industry supply chain is a mixture of many organisations in a supply chain. Therefore, the planning and management of supply chains require the appropriate responsibility of the participating members and identifying relationships to one another (Cheng et al., 2010). The same authors' further point out that the task is especially challenging in the construction industry because construction supply chains are complex in structure and are often composed of a large number of participants who work together in a project-based temporary manner.

3.7. Construction Supply Chain Structure for the UK

The UK construction industry supply chain structure has many (Tier 2) suppliers and sub-contractors BIS (2013c). It is also clear that there are at least three tiers in construction supply chain with the main contractor being Tier 1 and the sub-contractor being Tier 3. As the transactions between the Tier 1 and Tier 2 contractors increases the potential for supply chain fragmentations increases.

It is notable that the first two tiers, Tier 1 and Tier 2 are likely to be engaged in management activities such as procurement and the Tier 3 is where actual delivery of construction work takes place.

Some industry researchers have indicated that there were only a limited number of frameworks for representing the UK construction industry supply chain structures. According to Lambert and Cooper (2000) a supply chain map includes:

- Supply chain members
- Structural dimensions
- Type of business processes

Similarly, supply chain model framework was proposed by the Global Supply Chain Forum (GSCF), giving eight key business processes, which include:

- Customer service management
- Supplier relationship management
- Demand management
- Order fulfilment
- Product development

- Manufacturing flow management
- Product development and Commercialisation
- Returns management

The frameworks developed for supply chain are likely to vary because of the characteristics of different manufacturing sectors and the characterisation of management functions. That is, in the construction sector, the majority of companies are SMEs which in many instances do not have a clear understanding of the whole of the supply chain (Cheng et al., 2010). The report by BIS (2013) and the small business survey had highlighted that the majority of construction companies (that is, 72% in 2012) were family run businesses and around 20% of businesses were less than five years old. Moreover, an average of 29% of businesses had no work address and could be working from home. For the UK construction industry supply chain SMEs employ on average 12 employees and most work on a project basis.

Based on the facts that arose from the survey by BIS (2013), a supply-chain framework that required the interaction of cross-functional units may not be suitable for the UK construction industry supply chain framework.

To standardise, measure and improve the supply chain, the Supply-Chain Council (2008) put forward another framework, the "Supply Chain Operations Reference" (SCOR).

The SCOR modelling framework depends on five key supply chain processes:

- Plan,
- Source
- Make
- Deliver

The SCOR model is further structured into four process levels. That is, the first three levels, 'Scope, Strategies and Steps' are claimed to be applicable across industries but the fourth level 'Activities' can be industry specific. SCOR does not describe all business process or activity (SCOR, 2008).

Furthermore, this framework had not addressed issues such as research and technology development or product development; and had assumed the presence of quality, information technology or administration (SCOR, 2008). In fact, Cheng et al. (2010) had stated that SCOR was a generic supply chain operation reference model to use for fabricating various Supply Chains. SCOR (2008) presents five main attributes of a supply chain performance matrix, namely:

- Reliability: A customer-focused approach which addresses the ability to perform tasks as expected. This focuses on the predictability of the outcome of a process. The typical matrix of reliability is on-time, at the right quality and quantity.
- Responsiveness: A customer-focused approach which describes the speed at which tasks are performed, such as, cycle time (a term in Lean Manufacturing).
- Agility is a customer-focused approach that describes the ability to respond to external influences and the ability to change, for example, to manage fluctuating demand, labour issues, downtime, etc.
- Costs, internal focuses, describe the cost of operating the process. This includes labour, materials' transport and operational costs.
- Assets management efficiency describes the ability to utilise assets and is mainly an internally focused attribute aimed at reducing inventory and outsourcing.

In the SCOR the supply chain performance matrix attributes vary from one process to another; that is, in the Knowledge Management process, within a supply chain, it considers knowledge as an asset or knowledge as stock. In this situation, the performance of the construction industry supply chain elements features describes the ability to utilise the knowledge asset and the growth in knowledge asset and stock. However, some members of the construction industry supply chain consider the SCOR to be the most suitable framework for construction supply chain. It is believed that this framework allows the modelling of the supply chain structure and the relationship of processes in coherent manner. This is in addition to the performance measurement the performance measurements features concentrate on the customer and therefore seeks to provide value.

The SCOR framework has four levels of supply chain development; and the fourth level is unique for each organisation. Furthermore, this framework is relevant for the UK construction industry supply chains.

According to Court et al. (2012), In addition to construction industry supply chain there is increasing awareness that the construction supply chain's performance can be improved by adopting Lean or Agile. More specifically, the Lean concept thinkers (Pheng & Fang, 2005; Owen & Koskela, 2006, and Sacks et al., 2009a, 2009b) recommend that the construction supply chains could have the ability to perform better by adopting the lean approach. The Agile manufacturing supporters have been proposing that a construction supply chain is required to be responsive. Moreover, adopting agility would help construction industry supply chains deliver value to the customers (Court et al., 2012; Ribeiro & Fernandes, 2010 and Khalfan et al., 2007).

An alternative group of industry practitioners has highlighted the areas of improvement that can be achieved by using Lean and Agile processes in construction industry supply chains (Court et al., 2012; Rahimnia & Moghadasian, 2010; Sanderson& Cox, 2008). This group has further recommended that wherever practical, use both the Lean and Agile processes and in the process reduce the major influence of fragmentation.

In addition to reviewing relevant literature, this study presents the different types organisations and product suppliers within the UK construction industry supply chain; since it is conceivable that the size and type of the business may also hinder collaboration and partnering within the construction industry supply chain.

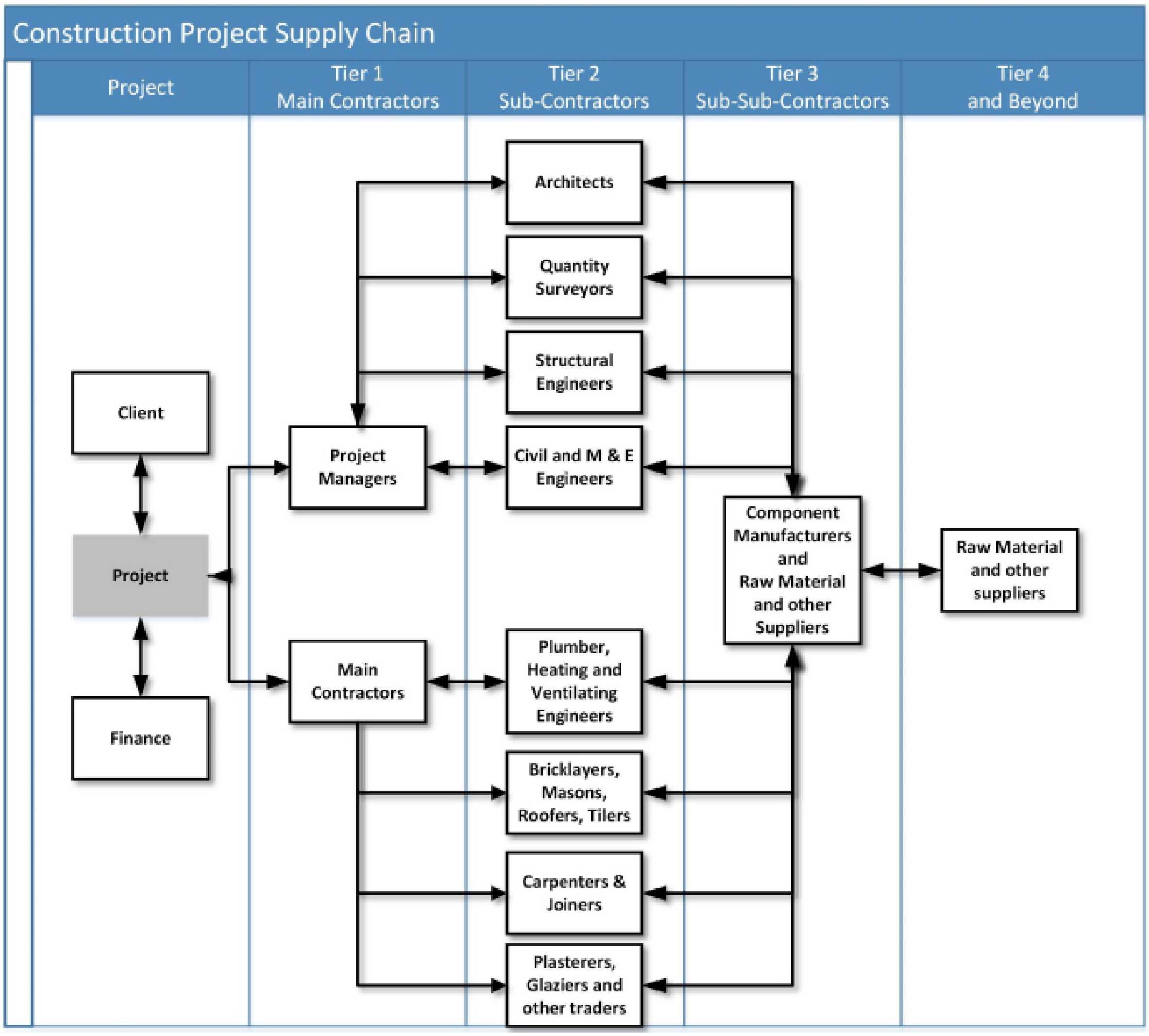


Figure 3.4 Levels within the Construction Project Supply Chain (Source: Developed from BIS, 2013; RICS, 2011; H M Government, 2014)

Since the construction industry supply chain is a complex and multi-organisational supply chain in which there can be many suppliers as a mixture of Tier (1), Tier (2), and Tier (3) and so on. The member of a construction supply chain as presented by RICS (2011) is shown in Figure 3.4. Also, HM Government (2014) had released a construction sector infographic, Figure 3.5.

In a construction industry supply chain, product suppliers, project management, main contractors and finance staff play the foremost roles.

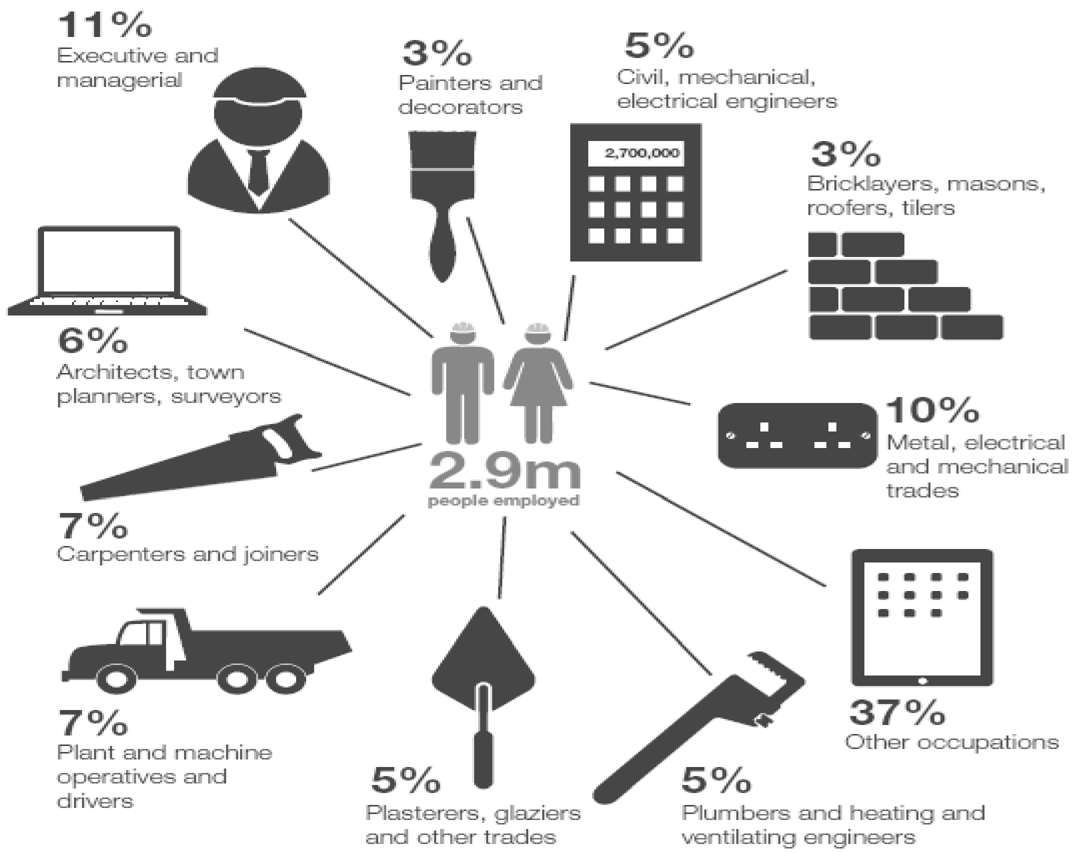


Figure 3.5 Breakdown of the nature of businesses within the construction sector (Source: H M Government, 2014).

3.8. The UK Construction Industry Supply Chain Challenges

Briscoe and Dainty (2005) had stated that the construction industry remains characterised by adversarial practices and disjointed supply chain relationships. This view was also echoed by Xue et al. (2007) when they had also said that the construction industry is generally categorised by high fragmentation and low productivity.

According to ONS (2014), the main reason for having many involved within the construction process is that about 99% of the UK construction industry is made up of SMEs. As Caballero et al. (2012) had indicated this issue is further intensified by the fact that the construction process predictably involves many specialised disciplines such as architects, quantity surveyors, structural engineers, mechanical and electrical engineers and sub-contractors; in some ways this initiates the practice of sub-letting the sub-contractors company's for a construction project. Wu (2009) had concluded in a study that the sub-letting practices within construction are in some ways more profitable for construction industry participants. Some argue that the fragmentation in the construction industry enables SMEs to contribute and survive in the competitive industry. According to Xue et al. (2007), the construction industry struggles to respond to change and to increase the performance of the construction industry supply chain. Despite the benefits of having fragmented supply chains, the literature review clearly articulates some of the drawbacks of a fragmented construction sector.

Factors/Challenges supporting fragmentation of CSCs	Supported Reading
Large number of small and medium companies	(Arditi et al., 2000; Blake et al., 2004; Sanderson & Cox, 2008; Coakes & Clarke, 2005; BIS, 2011)
Lack of skills and knowledge of collaboration and partnering	(BQF, 2013; Guo, 2012; Love, Irani & Edwards, 2004; Martinkenaite, 2011; Suresh & Egbu, 2006)
Traditional way of working/lack of business knowledge	(Arditi et. al., 2000)
Lack of funds to support organisational growth	(BIS, 2011; BIS, 2013b; Brigitta, 2012)
Short lifecycle of construction projects	(Arditi et. al., 2000; Race et. al., 2012; Rezgui, Boddy, Wetherill & Cooper, 2011; Scavarda, 2006)
Lack of awareness of Knowledge Management	(Alavi, 1999; Alavi & Leidner, 2001)
Lack of support available to small and medium firms	(BIS, 2013a; Lehtimäki et al., 2009; Adetunji, 2005)
Lack of awareness in seeking support	(BIS, 2013b)
Lack of learning capabilities	(Tsai, 2001; Baets, 2005)
Lack of decision making knowledge	(Baets, 2005; BIS, 2011; Adetunji, 2005; Sigala, 2008)
Lack of organisational strategies for competitive advantage	(Maier, 2007)

Table 3.1 List of factors/challenges supporting the main and sub-causes of fragmented construction supply chains (Source: Saini M. 2015)

The construction industry fragmentation within the design, fabrication and construction practices could be experienced through cost, time and quality-related issues. However, this often leads to unnecessary liability claims and other issues such as a lack of integration, collaboration and coordination between different functions and results into poor communication between partners. The Table 3.1 shows a list of supporting factors/challenges which jointly increase the problem of fragmentation while supporting the main and sub-causes of the disintegrated construction industry supply chain (Saini M, 2015).

Challenges	References
Lack of Trust, Mutual Suspicion, Hidden Agenda, Respect Others, Lack of common purpose, Lack of Project Goals, conflict objectives, Absence of the project goals	Wilding & Humpries (2009); Ward & Holti (2006); Olsson (2000); Ahmed et al (2002); Saad et al. (2002); Jone & Saad (2003); Wong et al. (2004); Benton & Mchenry (2010); Olsson (2000)
Different Culture & Procedure, Mindset, Blame culture , resist Innovation, Resist change, Traditional role thinking	Akintoye et al (2000); (Awad & Nassar, 2010);Matipa & Siamuzme (2005); Ahmed et al (2002); Saad et al. (2002): Jone & Saad (2003); Wong et al. (2004); Benton & Mchenry (2010); Ward & Holti (2006); Olsson (2000); Nicolini et al.(2001); Shelbourn et al.(2007); Ahmed et al (2002)
Lack of Commitment from seniors managers, Project Manager Planning	Akintoye et al (2000); Brown (1999); Suhol & Peter (2004)
Adversarial contractual relationship, Long time to establish relationship, Lack of guidance creating alliances, Incompatible Collaborative capability, Too dependent on Mutual Agreement	Jone & Saad (2003); Wong et al. (2004); Benton & Mchenry (2010); Brown (1999); Matipa & Siamuzme (2005); Wilding & Humpries (2009); Saad et al. (2002)
Power imbalance	Saad et al. (2002)
Communication, Sharing ideas, Lack of openness and opportunistic behaviour, Lack of Open book	Akintoye et al (2000); Wilding & Humpries (2009); Saad et al. (2002); Shelbourn et al.(2007); Saad et al. (2002)
Procurement systems	Jone & Saad (2003); Wong et al. (2004); Benton & Mchenry (2010); Matipa & Siamuzwe (2005); Furgues & Koskela (2009); Dainty et al. (2001); Nicolini et al. (2001)
Lack of Contribution of SC (Ignorance of SC)	Jone & Saad (2003); Wong et al. (2004); Benton & Mchenry (2010);
Client Wishes difficult to understand, Client lack of roles, Long procedure, Client responsibility	Matipa & Siamuzwe (2005);
Conflict in project information	(Li, Guo, Skibniewski, and Skitmore, 2008); Ahmed et al (2002); Suhol & Peter (2004)
Lack of design involvement	(Forgues & Koskela, 2009)
Absence of code of practice, Professional indemnity	Nicolini et al. (2001)
Selfish interest, Morale & Motivation, Ownership, individualism	Furgues & Koskela (2009); (Shelbourn, Bouchlaghem, Anumba, & Carrillo, 2007); Suhol & Peter (2004); Saad et al. (2002); Krisilia et al (2007)

Table 3.2 The challenges of integration supply chain (Abd Shukor A S et al, 2014)

It is to be noted that, this list of supporting factors is not exhaustive; there could be many more supporting causes in each discipline of organisational level and others at the construction industry supply chain level.

Abd Shukor A S et al (2014) had conducted a research to identify the key problems in the construction industry in Malaysia and had classified the possible problems into sixteen significant themes and pointed out that the industry had not been very successful in their attempts to find the right solutions to the challenges encountered whilst indicating that the supply chain and procurement to be the root of most problems –

> *Risks and conflict liability; guidelines and requirement matters; attitude and relationship matters; communication and information matters; contractual and procurement matters; lack of skills and knowledge; financial matters; technical matters; communications and information matters; guidelines and requirement matters; lack of skills and knowledge; financial matters; technical matters; risk and conflict liability; contractual and procurement matters; and attitude and relationship matters.*

Subsequently, Abd Shukor A S et al (2014), had carried out literature review on the challenges of integrating supply chain; these are presented in the table 3.2

3.9. Options for Addressing Construction Supply Chain Challenges

During 2004, the report “Partnering in Practice” (Brewer and Johnson, 2004) by Price Waterhouse Coopers and HM Treasury Standardisation of PFI Contracts Version-3 had recommended that there was a real need to define and communicate better to enhance partnering and collaborative working for public-private partnering (PPP) within the UK construction industry supply chain. The report had also emphasised that partnering allows the public sector to combine its skills and resources with those of the private sector. The report had concluded with the three types of potential partner grouping in the construction industry supply chain:

- Bilateral partnering: applies between the client and the main contractor.

- Multi-party partnering: applies between the client, main contractor and key sub-contractors.
- Supply chain partnering: this applies between all the parties (main contractors, sub-contractors and sub-sub-contractors) excluding the client.

This report had presented the following key determinants in the success of choosing supply chain partners:

- Contractor’s willingness to engage in a partnering relationship
- Contractor's previous experience of partnering
- Contractor’s understanding of the client business and the project objectives
- Contractor's ability to work together at personal and team level
- Effectiveness of management and governance in supporting the partnership and building the relationship
- Contractor's ability to demonstrate “Value for Money” (VFM)

Additional examination of literature on the construction industry and its supply chains and lean and agile concepts indicates that there is a general lack of awareness and understanding about the roles and contributions that Knowledge Management (KM) plays in collaborative and integrated approaches to construction supply chains and Lean and Agile processes and the importance of the efficiency of construction supply chains. There is clearly a lack of empirical research within this area, especially in the context of KM in lean and agile processes for the construction industry. There are several problems and challenges indicated in studies:

- A lack of trust and commitment
- A lack of public-private partnerships (PPP)
- A lack of efficient processes
- A lack of standardisation

Some researchers had considered problems of the disunited supply chain, the lack of integration and collaboration and insufficient knowledge management systems and whether they were either dependent or related to each other (Alashwal et al., 2011; Taylor et al., 2012). These authors further observed that the fragmented nature of construction supply chains was due to a lack of process integration and a lack of partnering and collaboration (Alashwal et al., 2011; Ribeiro and Fernandes, 2010; Hughes et al., 2002 and Orange et al., 1994). Some authors such as Taylor et al. (2012), Alashwal et al. (2011), Khalfan & McDermott (2007) and London and Kenley (2001) argued that a lack of process integration and partnering and collaboration in the construction supply chains was because of insufficient knowledge management systems. The literature on construction industry supply chains suggests that the existing knowledge management systems fail to transfer and share implied knowledge.

It is to be noted that some literature points out that knowledge management and skills are required in construction industry supply chain to enable integration within the construction supply chain efficiently (Kivrak & Arslan, 2008; Maqsood et al., 2003). Furthermore, Alashwal et al. (2011) had suggested that the negative impact of fragmentation could be reduced by developing a knowledge sharing approach in a construction industry supply chains. The problems in construction industry supply chains were caused by a lack of transferring and sharing implied knowledge and results in developing wasteful knowledge management systems (Alashwal et al., 2011). A poor or incompetent knowledge management system enhances the lack of trust and commitment among the stakeholders and leads to inactive collaboration, a lack of trust in the partners and inefficient process integration in construction industry supply chains (Hughes et al., 2002).

It is clear that some of the construction industry supply chain studies indicate that a lack of partnering, collaboration and integration were the negatives manifestations of the fragmentation in construction supply chains. It is possible that this was because of a lack of skills and awareness of knowledge communication.

The interrelationships between the main and sub-causes of fragmentation in construction supply chains, the supporting factors and the challenges are listed in the

Table 3.2. Each section in this table highlights the challenges that hinder the transfer and sharing of implied knowledge in construction industry supply chains.

Challenges	Causes	Supporting factors/challenges
Section (1) Fragmented Supply Chains	1-A Lack of Partnering and Collaboration 1-B Lack of Process Integration	• Large number of small and medium companies • Lack of skills and knowledge of collaboration and partnering • Lack of motivation • Lack of trust and commitment • Short project lifecycle
Section (2) Lack of Effective Knowledge Management Systems	2-A Lack of Trust and Commitment	• Lack of support available to small and medium firms • Lack of awareness in seeking support • Lack of learning capabilities • Short project lifecycle • Short term supply chain relationship
	2-B Lack of Motivation	• Lack of human resource capabilities • Lack of organisational strategies • Lack of reward system
Section (3) Inefficiency in transferring and sharing tacit knowledge	3-A Lack of Knowledge Transferring and Sharing capabilities 3-B Lack of Awareness of Knowledge Transferring and Sharing	• Lack of organisational capabilities • Lack of learning capabilities • Lack of awareness of gaining competitive advantage through KM • Lack of financial resources • Lack of awareness in seeking support • Lack of awareness of Knowledge Management

Table 3.3 The Inter-relationship of the main and sub-causes of fragmentation in construction industry and the supporting factors and challenges (Saini M, 2015)

Based on the findings given in Table: 3.2; Figure 3.2, below presents the inter-relationship between the problem and the causes of fragmentation in the construction sector.

It is to be noted that due to the nature of this study, the list of supporting factors is restricted to those that arguably impact the transfer and sharing of implied knowledge in construction supply chains. That is:

- The fragmented construction industry supply chains;
- Lack of construction process integration in construction supply chains;
- Lack of partnering and collaboration in construction supply chains;

- Lack of effective knowledge systems in construction supply chains;
- Lack of motivation for the workers, lack of trust and commitments among organisations and individuals in construction supply chains;
- Insufficiency in sharing and transferring implied knowledge in construction supply chains;
- Lack of awareness of knowledge transfer and share in organisations and construction supply chains;
- Lack of knowledge transfer and sharing capabilities within firms and construction supply chains.

The Figure 3.6 exhibits the causes of the fragmented nature of construction supply chains and the inter-relationships between the different elements. The Figure is broken down into three sections, namely 1, 2 and 3.

- Section 1 shows the major problem as being the disunited nature of construction supply chains. The disconnected nature of construction supply chains is an effect of the causes (1-A and 1-B) shown within the section 1. Lack of partnering and collaboration and lack of process integration in a construction supply chain supports and leads to fragmented construction supply chains. These causes are the direct causes of fragmentation but are also supported by the third principal cause of section 2, Lack of effective Knowledge Management Systems (KMS).
- In section 2, the foremost cause is the lack of KMS in construction supply chains which in itself is an effect of two sub-causes, namely: lack of trust and commitment among organisations (2-A) and lack of motivation (2-B) to share knowledge.

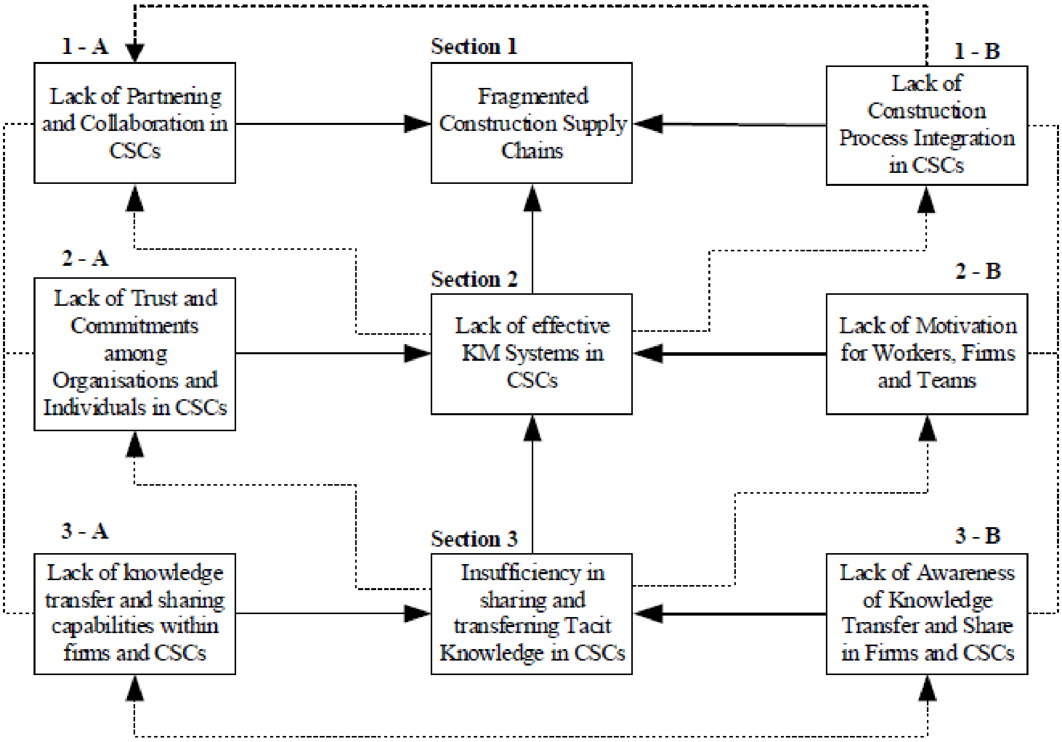


Figure 3.6 Problem, Causes and their interrelationship in the fragmented Construction Supply (Saini M, 2015)

That is the lack of trust and lack of commitment leads to inefficiencies and failure to share the implied knowledge. This is further supported by the sub-causes, namely, the lack of knowledge transferring and sharing capabilities (3-A) and the lack of awareness of knowledge transferring and sharing in construction supply chains (3-B).

3.10. Impact of Sustainable Construction in the UK

Adopting sustainable construction models within the growing construction industry in Britain has got great capacity to impact every stratum of life and space in the country as well as deliver on national and global sustainable development objectives (Plank, 2013; Steel Construction Institute, 2012). Although the uses of primary construction materials like wood timber, rock, aggregates, concrete and steel have significant environmental implications arising from their extraction, processing stages, logistics and transportation, utilization and final disposal, on the other hand, there is clearly very little practical guidance available to fluvial construction on best way to assess their impacts (Masters, 2001). Worst of all, there is quite a small dose of information accessible to engineering practitioners about the utilization and durability including the relevant environmental impacts of deploying reclaimed and recycled materials into the construction sector (Masters, 2001). However, Opoku and Ahmed (2015) disagrees and postulated that the paramount thing is to reduce carbon emissions and control the negative impacts it might have on the environment therefore sustainable designs and construction may be clearly cheaper to operate, run and arguably provide safer and healthier living environments.

Agreeing with the above submission, an aspect of the United Kingdom government sustainable construction policy and perhaps other countries elsewhere which may have also adopted sustainable construction policies, land recycling seems to have gained notability because lands already impacted by human activities are reused rather than green fields (farm land) for construction purposes (Kibert, 2012). Underpinned by this therefore, other scholars believe that adoption of sustainable construction approach is considered as a contribution of the construction industry towards the advancement and achievement of the larger objectives of sustainable development which is delivery of healthy built environment by forestalling environmental degradation (Ding, 2012). Furthermore, to control or adequately measure the environmental consequences of sustainable construction in the building life cycle could be achieved through three scales such as; the global environment, for environmental consequences on a global scale as well as the local and indoor environments for local and indoor scales (Evangelinos and Zacharopoulos, 2013). Consequently, El-Gamal et al. (2010) opined that built facilities have many overt and hidden impacts on the environment throughout their life cycles such as; spatial displacement of natural ecosystems, depletion of matter and energy resources from natural ecosystems and the obvious generation of quantum volume of waste during the entire life cycle of the building. El-Gamal et al. therefore (2010) suggested that waste could be recovered through a deliberate and calculated reduction in extraction and use of primary raw materials, reuse of relevant materials including land and recycling of waste from demolition sites. Above all therefore, the environment might not be impacted when sustainable construction occurs within the natural parameters of the ecological systems because the natural systems avails all the resources needed to enhance all human activities (El-Gamal et al. 2010).

Furthermore, consistent with the United Kingdom's government and construction research organization (CIRIA) guide lines, the construction industry seeks to mitigate the impacts of its activities on the environment to attain sustainability through investment in wider economic viabilities and growth whilst promoting efficient working practices (Shiers and Keeping, 2009). However, this contradicts the views expressed by 7group and Reed (2011) who argued that the average construction worker does not understand how efficient working practices hinders delivering of sustainable construction due to poor information on sustainable development and how practical efficient working practices helps to achieved it. According to Steedman (2011), the United Kingdom's government sustainable construction strategy clearly outlined four key points such as biodiversity, water, waste, and carbon as part of wider elements set to address "the means" and "The ends" for the construction sector but it is interesting to note that many construction firms actually fail to follow these strategies to reduce impact on the environment (7group and Reed, 2011). However, Myers (2013) disagrees stating that construction firms in Britain faces quite a high landfill taxes designed to encourage sustainable raw material extraction and recycling in compliance with government directives therefore they actually follow relevant directives.

Following from the above, sustainable construction has impacted many British communities because individual building projects does have significant social implications in a community (National Audit Office, 2007). Unfortunately, the United Kingdom's government and industry broader strategy for sustainable construction, in practice, often supports the business case for sustainable construction resulting in increased profitability for businesses who use resources more efficiently and enhancement of business image and profile in the market place (Domone, 2010; Moore and Ochieng et al., 2013). Thus, there have been many concerns at the failure of some guidelines and manuals to create strategic synergy between social, economic and environmental sustainability (Moore and Ochieng et al., 2013; Uren et al. 2000).

Arguably, the government construction policies sometimes mandates construction firms through relevant councils to network with individual household and communities at large who may be in receipt of any major construction projects in order to mitigate any unforeseen social impacts (Higgon and Loosemore, 2015; Moore and Ochieng et al. 2013).

It is instructive to note that the involvement of local communities from the conceptual stages, construction and delivery of construction projects increases efficiency and creates a sense of communal ownership of such projects and meets the needs of the end users which contribute to project operations including maintenance cost (Moore and Ochieng et al., 2013). Conversely therefore, evidence suggests that construction projects that are centrally planned and executed without inputs from end users and local communities stands a higher chance of failing and faces poor maintenance (Moore and Ochieng et al. 2013). Contrary to the above, Kibert (2012) posited that some construction corporations acknowledge social impacts of their projects and therefore work to ensure improvement across all arenas. Furthermore, du Plessis (1999 as cited in Ding, 2012) advocated that social impacts should occupy a pivotal role within the concept and accomplishment of sustainable construction because social achievement underpinned by improving quality of life is the motivation for many actions therefore more development and growth should lead to a corresponding increase in living standards.

In other words, society should not just concentrate on economic growth and development but rather, it should be deliberately conscious about the long term impacts of its activities on the standard of living of present and future generations (Ding, 2012). This postulation widely agrees and is consistent with the view that the financial decisions of many construction corporations constantly have wide-ranging social implications partly because of their belief that they cannot afford to build in a sustainable manner due to cost hence potential social impacts are often neglected (Halliday, 2008). According to another commentator, the forms and manner including the quality with which, cities, towns and villages are constructed evidently have quite a huge implication on people's quality of life, thus the architect, particularly the building designers plays critical and strategic roles in construction to deliver social, cultural and economic needs of a sustainable community (Talbot and Morgan, 2013).

Also, the construction industry plays a crucial role in the economic well-being of the European Union representing approximately 11 percent of the community gross domestic product (GDP) (Eid, 2013). However, a small number of leading United Kingdom construction companies are undertaking operational reorientation and structural adjustments because they believe it is essential for their economic viability (Eid, 2013). Drawing from this point, the construction sector contributes approximately 10 percent of the United Kingdom gross domestic product therefore represents a strategic cornerstone of the British economy, although, most economic considerations are directed by prevailing market prices (Steel Construction Institute, 2012). This economic appreciation is coming despite the problems the United Kingdom construction sector suffered between 2008 -2010 due to the global financial meltdown (Wilkinson, 2015).

3.11. The Role of Wood in British Construction Industry

According to Coulson (2011) and also agreed to by Appleby (2012) although the British construction industry is a big consumer of wood materials that grows within the tree, instructively this sector is by far the largest user of wood timber (soft and hard), in terms of volume, in the world. It is approximated that 50 million cubic meters of wood timber is used within the United Kingdom annually and the British construction industry consumes up to 70 percent of the softwood used (Appleby, 2012). This therefore suggests that wood has been playing significant roles in the history and development of the British construction industry for a long time (Coulson, 2011; Appleby, 2012). Subsequent upon this therefore, the role of wood in meeting set Britain and global sustainable development objectives cannot be over emphasized, when usage of this vital material is organized (Brack, 2014; Sawe, 2011). However, contrary to this view, Freed (2011) and Woolley (2013) who argued more on alternative approaches opined that the increased usage of wood and wood timber especially as key construction material has hindered the development of innovative ideas amongst British construction professionals on creating improvised alternatives that could achieve the same aim and objectives. Although Valen and Moum et al. (2014) argued that architects and engineers, through some government and research and education programs in countries like Norway, have begun to receive teachings about innovative ways of using wood as sustainable building material rather than alternatives.

Arguably, this high preference and demand for wood timber within the British construction sector and Europe have largely contributed to global depletion in strategic forest reserves especially in places such as Sub-Saharan Africa, tropical America and India (Sands, 2013; Environmental Audit Committee, second report, 2005-06 as cited in House of Commons Environmental Audit Committee, 2009). This is particularly so as reflected in the increased level of wood timber wastages in the British construction sector when using plasterboard as a case in point (Appleby, 2012). It is argued that the plasterboard wastage within the British construction sector has been conservatively put at over 300,000 tons of the 2.3 million tons of new plasterboards installed per annum within approximately four million tons of waste wood including an additional 1 million tons of materials sent to landfill sites from construction, demolition and refurbishment projects (Appleby, 2012). Hence, the nature and characteristics associated with the role wood or wood timber plays within the larger construction industry including its attendant benefits have been generating controversies across various academic disciplines and between practicing construction professionals over the years (Freed, 2011; Coulson, 2011; Miller and Kenneth, 2013). Some have argued that using wood for construction is not environmentally sustainable and roundly defeats the concept of sustainability because it involves a wide range of adverse impacts, including the depletion of critical forest reserves with attendant effects on the ecosystems around the world (Sands, 2013; Chew, 2001).

Scholars belonging to the above school of thought opined that mass usage of wood for commercial construction will continually lead to unquantifiable economic loses characterized in the process of hewing down of trees (Chew, 2001; Garcia, 2005). Conversely, other commentators such as Coulson (2014) and Sawe (2011) postulated that wood is a renewable source with proven low embodied energy therefore its usage is environmentally responsible and a practical construction material. Therefore suggesting that the best way to achieve green housing initiative and substantially mitigate against the emission of greenhouse gases (co^2) is by encouraging the construction industry to adopt the strategy of using wood in key construction projects (Coulson, 2014; Sawe, 2011; Miller and Kenneth, 2013). However, yet another group of commentators opined that wood construction does more damage to the community than good when you consider the easy susceptibility wooden buildings have towards fire and the loss of human lives involved in such incidences (Masters and Maric et al. 2010). Despite these endless controversies of whether or not continuing with wood timber construction is environmentally sustainable and good for the larger construction industry, arguably British builders have increasingly and innovatively used wood and wood timber to complement the raw materials needed in the construction industry (Parker and Dickson, 2014; Law, 2010).

Following from the above therefore, it is instructive to note that wood and timber construction are not new to the British construction industry judging by various historical antecedents (Addis, 2012; Law, 2010). Consequently, the pivotal point is identifying and gauging the possibilities of creating measurable parameters which government and construction executives will sustainably use to check supply chain risk and vulnerability (Brindley and Ritchie, 2009). Also, another option could be by ensuring that relevant construction stakeholders close ranks with the construction supply chain sector to develop acceptable mechanism that would guaranty management of construction organizations that timber wood materials are sustainably sourced (Greenwood and Bouazza et al. 2015). Thus, this will strengthen the underpinning foundation upon which sustainable construction objectives could be met in the United Kingdom while sustaining acceptable international best practices in sustainable development (Greenwood and Bouazza et al. 2015). Thereby contributes to the preservation of the livelihoods of over 1.6 billion people mostly found (in Sub-Saharan Africa and Latin America) who live in the rainforest whose economic and social activities directly depends on forests resources through deliberate sustainable harvesting (planting three or four trees for every one fell) of timber wood (Coulson, 2014).

According to Garcia (2005) and contrary to many arguments raised above, the activities of wood and wood timber resourcing harvested from forest lands will continue into the nearest future fundamentally because of a corresponding increase in human population and expansions across global economies. This all truism will therefore remain a strategic clog in the wheel of achieving set global sustainable development targets (Greenwood and Bouazza et al. 2015). Thus, aligning with Sayigh's (2013) argument that Britain should take the early initiatives in reinventing the sustainable alternatives to wood timber being a key material resource needed in the British construction industry. Thereby, keeping sustainable development hope alive, this is the only known alternative to protecting the interests of future generations (House of Commons Environmental Audit Committee, 2011; Heredia and Manuel, 2014).

3.12. Aggregates and Cement Materials in British Construction

Many of the materials used for the production of construction materials requires the extraction of raw materials like concrete gravel, marble, limestone and sand to list a few from the natural environment hence arguably have consequences such as; degradation of the community landscapes where such extractions takes place therefore affects sustainable development (Thorpe, 2010; Taylor, 2000; Vitullo and Rumbarger, 2003). However, concrete, bricks, stones and cement (finished product from limestone) are the most versatile materials used across the construction industries including British construction firms (Taylor, 2000). Arguably, many if not all of these raw materials are not sustainably sourced through the processes of extraction, production and transportation stages of the supply chain before delivering same to the final construction consumer(s) (Vitullo and Rumbarger, 2003). Sand, gravel stones and rocks together are generally called aggregates in the construction sector and they are often not sustainably extracted since larger quantities of these are obtained from quarry pits (Domone, 2010; Rankin, 2011). Although OECD (2003) agrees that these construction aggregates are commercially extracted and or imported in large quantities and often through unsustainable processes, however, Britain has taken practical steps to address this situation as rightly pointed out by Guthrie and Runguphan (2009).

This unsustainable process has caused loss of valuable or scenic land including expulsion of dust and noise population within such rural communities (Domone, 2010; Rankin, 2011). The aggregate extracts from primary sources such as crushed rocks, sands and gravels from river or sea-bed deposits are known to trigger earth movement such as slides in rive shores because they are sourced in quantities greater than other construction materials used in concrete and asphalt and brickwork (Domone, 2010). They can also be extracted from other sources like by-products from other industrial processes or recycled previously used construction materials (Darling, 2011). It is instructive to note at this point that the initial two sources (primary and secondary) are quite inimical to achieving sustainable construction (Darling, 2011). Contrary to this view, the British Environment Agency (2000) and argued that the use of recycled aggregates in British construction industry would not in any way reduce the demand or extraction of same from primary sources because of the need to aggressively build new homes (put at 3.8 million between 1996 and 2021) to close the housing deficit. Unfortunately however, this point is consistent and observed in the poor achievements recorded in the initial steps taken by the United Kingdom since 2002 when it introduced aggregate taxation to serve as an economic incentive designed to mitigate the use of primary aggregates for construction (Domone, 2010).

Underpinned by these mixed experiences therefore, Guthrie and Runguphan (2009) postulated that there should be a complete paradigm shift in the use of primary aggregates in order to achieve sustainable construction industry in Britain given that the United Kingdom annual demand for construction aggregates is put at 250 million tons. Stressing further that the use of alternative construction materials like industrial by-products and waste materials such as Burnt Colliery Spoil (BCS) (waste material from coal mining industry) which are available in large quantities shows more sustainable ways in solving some of the aggregate supply problems (Guthrie and

Runguphan, 2009). However, Alexander and Mindess (2010) argued that Burnt Spoil Colliery are not sustainably extracted thus they are not sustainable alternatives to aggregates because they actually come from the process of mining and processing coal which creates deep pits in communities and destroys the ecosystem. Therefore industrial wastes such as slags, which are already in use in concretes, porous and low strength rocks and sintered salty clays dredged from the sea to list a few are some of other alternatives suggested (Brown, 1993 as cited in Alexander and Mindess, 2010). Unfortunately, these sources have effect on the environment and therefore has the capability to destroy the ecosystem, thus, the most economical and sensible sources for alternative aggregates still remains from demolition and building wastes which will help to produce a closed life cycle for concrete and building materials (Alexander and Mindess, 2010). It can therefore be argued that, the concept of sustainable development does not prohibit the use of raw materials, rather it insist that raw materials should only be extracted after the exhaustion of recycled materials as well as deliberate action taken to mitigate, possibly eliminate waste and demonstrate prudent use of naturally extracted materials (Sarsby and Serridge, 2011).

Sequel to the above, cement is a by-product or finished product from limestone which is mostly extracted by ripping, blasting although not commonly used, and processed by crushing and screening to produce crushed rock aggregates (Harrison et al. 2005) are quarried around the world for cement manufacturing, high grade building stones and agricultural lime (Huggett, 2013). This material which was once largely extracted from the British Yorkshire Dale Limestone Industries is generally considered one of the most indispensable building materials in the United Kingdom construction industry history since the Roman times when it was basically used for mortar (Johnson, 2010). Thus, the environmental impacts of the Limestone extraction within the host community and Britain at large cannot be overemphasized because sustainability was not considered then, although, Yorkshire area has produced many innovative entrepreneurs and the landscape is dotted with Limestone quarries and the land used as landfill sites (Johnson, 2010). Instructively, Huggett (2013) opined that Limestone quarrying has destroyed British karst areas, caused water pollution and has also destroyed some British Limestone caves.

Unfortunately, all the processes contained in cement production contribute significantly to the overall global emissions levels of greenhouse gases, for instance in 2006 it was observed that cement production accounted for around 5.5 percent of the global CO_2 emissions mainly because of the high temperature required to decompose carbonate to calcium oxide and carbon dioxide (Domone, 2010). However, according to British Cement Association (2008 as cited in Domone, 2010) Britain within the last decade from 1998-2007 has taken proactive steps to deliberately reduce CO_2 emission as a result of activities from cement plants from 0.92 to 0.82 kg/kg cement including the reduction in NO_x. Despite these, Hutchinson (2014) views are consistent with the findings by Market and Opinion Research International (MORI) that British commitment to achieving sustainable environment is below expectation giving that captains of industry do not pay sufficient attention to the environment, though they may regard environmental issues as germane. Accordingly therefore, it could be argued that government and organizational policies on environmental sustainability, despite the behavioural change agenda, are not quite far reaching enough in Britain (Peters and Fudge, 2013). Evidence tends to suggest that where such policies do exist their implementation is skewed in favour of big businesses (Royal Commission on Environmental Pollution, 2007). Hence, it is almost certain that the pollution caused by cement production will continue giving the thousands of homes that needs to be built between now and 2021 in Britain (British Environment Agency, 2000).

Therefore, some commentators argued that continued reliance on cement (especially the widely used Portland cement) and the massive increase in global production level will hinder the delivery of sustainable construction in the United Kingdom and globally partly because of over dependence on fossil fuels (Flammini and Sims, 2014; Acton, 2012). This can only be contained except a suitable alternative construction material that will strategically replace cement and which will require less energy and contains less pollutant (such as satellite technology) is discovered (Acton, 2012). Also, construction stakeholders including relevant government should agree on other alternatives like the commercial use of carbon negative cement (CNC) made from magnesium silicate which does not generate CO_2 rather absorbs it while in use and Alkali-activated cement which does not require a kiln and uses less energy (Binggeli, 2013; Guertin, 2011). Conversely, Leong (2015) argued that regardless of what materials are used for construction, the problem remains that construction organizations and the whole supply chain must reinvent the entire raw materials manufacturing processes to reduce energy and unnecessary wastages in the construction chain which will partly contribute towards delivering a sustainable construction sector.

3.13. British Steel Construction Industry

Following from the above, British steel has witnessed growth and inherent problems inimical to sustainable construction such as the iron and steel making in the Tees valley which represents the second largest steel manufacturer in the world and the industry is germane to both the British and sub-regional construction sub-sector and economies (Parliament House of Commons, 2010). Although this product is generally perceived as crucial to national economic growth and perhaps the future restoration of sustainable economic prosperity in Britain, there is no doubt that the manufacturing processes involved are not environmentally sustainable like heavy land contamination, high dependant on fuel (Birch, 2013; Parliament House of Commons, 2010) and pollution levels (Woods, 2010). Conversely however, Lipsey and Chrystal (2015) and also agreed by Pope (2013) argued that the British steel industry has dropped and declined in production behind countries like the United States and Germany because the government has failed to invest in it and the absence of trained technical workers. Fundamentally, steel represents an ideal modern material used for the building of houses and other critical infrastructures that are constructed in contemporary times (Freed, 2011). It can be argued that, the need to reduce the demand for primary aggregates in the developed world, based on anticipatory shortages, fired up the shift and advances in the use of steel for construction in the developed economies unlike in the developing countries (Alexander and Mindess, 2010).

In principles, the British government has developed frameworks upon which steel manufacturing would be done sustainably considering environmental and climate change issues (Parliament House of Commons, 2010). Unfortunately these principles are not been adhered to in practice, because many steel manufacturing industries are not professional in their approach to sustainability (Blowfield, 2013), and relevant regulatory bodies need new approaches for better compliance results (Marzilli, 2009; Refaee and Altan, 2014). Based on this, some scholars believe that 'sustainable construction' or sustainability as it were, has become like a cliché hence does not actually mean anything to most erring company executives (Engelman, 2013). This is partly because many of such executives have either deliberately refused to follow the line of government due to cost to the business or because they might not have benefited from available incentives thus decides to neglect the implementation of relevant government policy directives (Blowfield, 2013). Given these complexities therefore, it is necessary to ask whether or not sustainability or sustainable development is still going to be possible, according to Engelman (2013; Yang, 2011). Arguably, the British steel industry CO_2 emission foot print is not encouraging and therefore calls to question the effectiveness of government policies vis-à-vis economic prosperity (Blowfield, 2013).

D'Costa (2013) argued that steel and steel based engineering have long been viewed as the strength and sinews of contemporary industrial and military powers, therefore the pollution caused by steel production and the amount of greenhouse gases globally emitted into the atmosphere especially by steel manufacturing countries cannot be over emphasized (Wiegman, 2012). Although steel manufacturing have literarily collapsed in Britain (Roberts, 2011; MacGregor, 2012), its construction sector still relied heavily on local production which is complimented with imported steel for construction of critical social infrastructures, industrial and military complexes (Kwan and Sansom et al. 2003). However, Plank (2013) argued that steel can be used to achieve sustainable construction in Britain through integrated approach with other materials, starting with extraction and sustainable use of renewable energy sources.

This assertion therefore clearly agrees with the views expressed by Steel Construction Institute (2012) who opined that sustainable use of steel materials can lead to correspondent reduction in the amount of aggregate and wood timbers needed to build homes and office complex including other critical social infrastructures. Yang (2011) stressed further that steel materials are easily recycled for secondary usage and currently 1/3 of the world steel production is got from recycling. Despite these gains in recycling steel products and steel building materials, Christopher (2013; Marzilli, 2009) opined that the best way to check and perhaps mitigate carbon dioxide spread in the atmosphere is by putting a price to every emission done by thousands of enterprises. However, failure to galvanize divergent steps to curtail the spread of greenhouse gases will result in a protracted trouble for a very long time given that there is no single path to capping greenhouse gases (Wiegman, 2012).

3.14. Supply Chain Innovation in the UK Construction Industry

Many scholars argue that the United Kingdom is a critical player and a formidable international partner in the innovative use of advanced technologies across different fields of human endeavour (Volti, 2013; Preston, 2014; Huelman and Hendricks, 2005). However, sceptics have roundly debunked and criticized this view arguing that the United Kingdom is slow and not doing enough in deploying its human and technological experience and expertise to aid global technological advancement especially in the sustainable industry sector mainly due to economic issues (Parliament House of Commons, 2008; Parliament House of Commons, 2010). This technological inaction on the part of Britain has also been attributed to lack of new innovations in the supply chain of construction materials because of lack of top management commitment (Dai, 2011). Some others believe that poor innovations in British sustainable construction sector are due to lack of germane discoveries in how to efficiently and effectively approach the sector particularly due to barriers such as; affordability, poor client awareness and demands (Pitt et al. 2009 as cited in Wilkinson, 2015). This is consistent with recent study which concluded that construction in Britain is still driven by cost reduction rather than value enhancement (Green Construction Board, 2015 as cited in Wilkinson 2015).

Conversely and despite these controversies, some evidence exist on the use of new technologies in driving the supply chain sector (Moore and Price et al. 2013) with a view of delivering a sustainable construction industry (Cotgrave and Riley, 2013) within the last twenty years in the United Kingdom. This has particularly been observed in the combined participation of raw material suppliers, the construction industry and manufacturers in the transfer and adaptation of aerospace/defence technology for the provision of a simple and economical manufacturing process using low cost materials (Burline, 1999 as cited in Halliwell, 2002). Another innovative instance is within the civil engineering construction sector where advanced fibre composites are embedded into a matrix which subsequently is applied externally as element of reinforcement to any existing structures (Keble, 1999 as cited in Halliwell, 2002). Arguably therefore, these strides are viewed as not far reaching enough and do not obviously demonstrate the capacity to tackle current challenges and impacts inherent within the sustainable construction sector in the United Kingdom (Green Construction Board, 2015 as cited in Wilkinson 2015; Parliament House of Commons, 2010; Dai, 2011). This therefore implies that it is important to understand how Britain's construction industrial sector has grown and what her contributions to sustainable construction over time has been (Richardson, 2013; Moore and Price et al. 2013).

Following from the argument above, the United Kingdom is generally viewed as one of the leading countries making attempts in using new innovations in supply chain management to drive modern developments in the sustainable construction sector (Moore and Price et al. 2013; Cotgrave and Riley, 2013). Some commentators argued however that, though the United Kingdom is contributing to current innovations in the supply chain management sector (Burline, 1999 as cited in Halliwell, 2002). However, many more deliberate actions like recalibrating the government construction policies (like done in the United States) needs to be taken to refocus the country in delivering on its sustainable construction objectives (Kibert, 2012). Contrary to the above the United Kingdom has witnessed some recent innovations in this sector by looking at ways that will improve sustainable supply chain management with the sole aim of reducing cost (economic factors) and improving services (value generation) to further enhance the sustainable construction industry (Rich and Holweg, 2010). One of such innovations is through elevating supply chain as equal with other business elements when setting up any business strategy because it often controls both large scale costs associated with the products and, through relationship management, the level that could be maintained with suppliers (Rich and Holweg, 2010).

Arguably though, innovation in this sector goes far beyond advocating one size fits all model rather the sector should undertake a deliberate attempt to improve the material design and flow of products to easy exploitation by the customer organization with a view to sustainably drive the sustainable construction sector (Rich and Holweg, 2010). Also, the British government has recently participated in financing the Advanced Manufacturing Supply Chain Initiative (AMSCI) which is another strategy designed to bring innovations into the British supply chain sector by making it more competitive and encourage new entrants to locate to the United Kingdom (2015). Instructively, this combined initiative by the United Kingdom Manufacturing Advisory Service and the UK Trade and Investments was designed within the context of Re-shore UK service program which assesses suppliers' capabilities; support their strategy formation and opening new supply chain entrant opportunities created by back-reshoring (Groom and Parker, 2014 as cited in Vastag and Stentoft et al. 2015). One implication of this initiative is to ensure that the construction industry in the United Kingdom was approached from a more strategic and competitive positioning like in France and other countries in Europe including the United States of America (Vastag and Stentoft et al. 2015).

Furthermore, innovations in global supply chain management has effectively compressed time and space, saved money and therefore positively affected sustainable construction deliverables through efficient and timely supply of raw materials to construction organizations and also eliminating the problem of distance and delays (Zuru and Mingqiang, 2011). The British construction industry supply chain management research group has evidently postulated that production planning, procurement, transport and storage facilities constitute very important aspects in the internal organization of supply chain management and should include the vital areas of continued innovation (Tyssen and Cetinkaya et al. 2011; Zuru and Mingqiang, 2011). However, construction supply chain designs should fit with the terms of divergent construction organizations underpinned by the fact that different materials needed within the sustainable construction sector and construction industry generally needs different supply chain design innovations for the sector to be competitive and deliver on its objectives (Jones, 2013; Cox and Ireland, 2012). Therefore agrees with Rich and Holweg (2010) argument that innovation in this sector goes far beyond advocating one size-fit- all model.

3.15. Impact of Brexit

Amongst the UK construction supply chain industry participants the opinion is divided on whether Brexit will affect large construction projects in the UK and some seasoned professionals from the UK construction industry are warning of troubled times ahead for the industry. However, it is worth noting that generally it is assumed that the infrastructure investments are low risk and are not normally affected by the financial market ups and downs.

However, for the UK construction industry supply chain fear and scepticism surround Brexit and as always uncertainty is not good for industry. In some cases it can be said that the Brexit has caused unwelcome confusion and over speculations. In short, it is considered to be additional concern for the UK construction industry supply chain which no one had predicted. However, the majority of the UK construction industry participants believe that it is an extra complexity that industry had predicted, but the long-term nature of our horizons for infrastructure investments would allow the industry to overcome this uncertainty.

The cost of the construction industry technologies and building products the cost is expected to go upwards.

It is also true that the UK construction industry professionals are highest skilled and these skills have no association with Brexit. The UK construction supply chain industry is also dependent on both skilled and unskilled labour. It is conceivable that local labour costs would go upwards if the UK is less able to access labour from overseas.

According to Raconteur (2017), the cost of materials is another worry - “sixty four per cent of the building materials used in the UK are imported from the EU. The EU is also the largest market for the construction materials we export, purchasing 63 per cent. Brexit will potentially lead to heavy duties or limits on quantities of materials.”

Nick Easen (Raconteur, 2017) stressed that pressure on space and affordability is driving the design and construction of micro-homes in crowded, heavily populated cities. With top-notch design, the construction of small homes can be an efficient use of space. They can also provide short-term solutions for cities looking to utilise plots that have yet to be zoned properly. There’s also great flexibility when it comes to the use of unexpected spaces. Smaller units are also easier to prefabricate, saving time and money on each build.

The pressure on project, commercial and design professionals to deliver evermore complex projects on time and budget continues to grow. Even with the availability of enterprise resource planning (ERP) to access financial control information more quickly, the challenge to all professionals in the construction industry is increasing.

However, the industry technology drivers have no boundaries and will continue to impact positively the UK construction industry supply chain - Smart sensors to track people, Radiofrequency identification to track equipment/materials, Robotics automated technology, Drones to monitor construction status, Building information modelling, remote monitoring on sites.

3.16. Summary

This chapter discussed the various approaches that the four countries (England, Scotland and Wales including Northern Ireland) within the United Kingdom uses to approach the issues of sustainable construction and construction supply chains issues generally.

The chapter considered different reports and studies (Latham Report “Constructing the Team”; BIS 2013c; Kagioglou & Cooper 2012; Hope 2012; Plank, 2013; Steel Construction Institute, 2012; Egan 1998) as well as the negative impact of fragmentation in the construction sector, supported by several sub-causes. The root causes such as the lack of collaboration and the lack of process integration within construction supply chain were also highlighted. How the collaboration and partnering within construction supply chains is led by a lack of knowledge management systems; and is supported by a lack of trust between organisations and lack of motivation among organisations and individuals. The main challenges which hinder the transfer and sharing of tacit knowledge in construction supply chain were discussed.

It also addresses how adopting sustainable construction models within the growing construction industry in Britain has got great capacity to impact every stratum of life and space in the country as well as deliver on national and global sustainable development objectives (Plank, 2013; Steel Construction Institute, 2012). The chapter pointed out that, although the uses of primary construction materials like wood timber, rock, aggregates, concrete and steel have significant environmental implications arising from their extraction, processing stages, logistics and transportation, utilization and final disposal, on the other hand, there is clearly very little practical guidance available to fluvial construction on best way to assess their impacts (Masters, 2001).

Underpinned by this therefore, scholars believe that adoption of sustainable construction approach is considered as a contribution of the construction industry towards the advancement and achievement of the larger objectives of sustainable development which is delivery of healthy built environment by forestalling environmental degradation (Ding, 2012).

Sustainable construction has impacted many British communities because individual building projects does have significant social implications in a community (National Audit Office, 2007).

The UK construction industry consists of a large number of small and medium enterprises which bring the negative impact of a fragmented construction industry (BIS, 2013).

Although majority of these companies participating in the supply chain are specialists in their fields; these organisations must learn to trust each other to share knowledge

(Martinkenaite, 2011); and need to understand that a construction project is not for monetary gains but it is also for developing intellectual capital (Narteh, 2008; Bou-Llusar & Segarra-Ciprés, 2006; Goh, 2002). Therefore, trust and motivation amongst the UK construction industry supply chain partners may boost the possibility that shared knowledge may bring benefit to other supply chain players and the construction project itself.

Chapter Four
Research Methodology

4.1. Introduction

This chapter will discuss the research methodology adopted in this study. The main focus is on explaining the 'how' of the research. In effect, the methodology adopted for the research. The chapter also includes the research approach used, the design of research, the motivation behind the selected research method and an explanation of the process used in the research.

4.2. An Overview of the Research Methodology and Methodological Framework

Research methodology refers to the theory and analysis of a research method.

Research methods involve; procedures, tools and techniques to be used in the research data generation and analysis (Schwandt, 2001). Any method engaged by any research is expected to give credence to the project embarked upon and justify the appropriateness of the selected methods for that particular research (Fellows and Liu, 2003). Furthermore, the principles and logic driving any research investigation refers to research methodology used to solve research problems (Fellows and Liu, 2008; Kothari, 2004 and Sridhar 2009). Therefore, research methods and methodology are useful for the effective conduct of this research which will address the set aim and achieve the stated objectives.

A conceptual framework for this research study will serve as the scope outlining and offering explanations for the structure of the methodology and the interrelationship between the research methods being employed. According to Miles and Huberman (1994) a methodological framework is a process that "explains either graphically, or in narrative form, the main things to be studied …the key factors, concepts or variables and the presumed relationship among them". Additionally, Bell (2005) and Globio (2012) emphasised that methodological framework is the main focus or structure on which a research is carried out.

The detailed structure and processes used in this research will be discussed in the following sections of this chapter.

4.3. Research Philosophy

This section covers Research Philosophy and how the research will be conducted.

Research philosophy deals with the development of knowledge, the nature of the knowledge and the assumptions on the way a researcher views the world (Saunders et al, 2007). According to Creswell (2007), research philosophies are grouped into three parts *ontology*, *epistemology* and *methodology.* On the other hand, Saunders et al. (2007) had emphasised that the three parts of research philosophies include; ontology, epistemology and axiology. Scotland (2012) had suggested a fourth concept as methods; that is outline and explore the interrelationships between each paradigm's ontology, epistemology, methodology and methods.

Ontological (What knowledge is)	
Objectivism (Realist)	**Idealist (Subjectivist, Social Constructivism)**
Epistomological (How We know it)	
Positivism	**Interpretivism**
Axiological (What research value goes into it)	
Value Free	**Values Laden**

Figure 4.1 The philosophical viewpoint of this research

In the main, Epistemology is concerned with the nature and forms of knowledge (Cohen et al., 2007). Epistemological ideas are concerned with how knowledge can be created, acquired and communicated, in other words *what it means to know.* Guba and Lincon (1994) had explain that epistemology asks the question, what is the nature of the relationship between the would-be knower and what can be known?

Every theory/paradigm is based upon its own ontological and epistemological assumptions or ideas. Since all assumptions are inferences, the philosophical underpinnings of each theory/paradigm can never be empirically proven or disproven.

Different theories naturally contain differing ontological and epistemological views; therefore, they have differing assumptions of reality and knowledge which underpin a particular research approach. This is reflected in resulting methodology and methods.

Methodology is the strategy or plan of action which lies behind the choice and use of particular methods (Crotty, 1998). Thus, methodology is concerned with why, what, from where, when and how data is collected and analysed. Guba and Lincon (1994) had explained that methodology ask the question: how can the inquirer go about finding out whatever they believe can be known?

Methods are the specific techniques and procedures used to collect and analyse the data (Crotty, 1998). The data collected is either qualitative or quantitative. All philosophies can use both quantitative and qualitative data.

Research methods can be traced back, through methodology, axiology and epistemology to an ontological position. It is impossible to engage in any form of research without committing, in some scenarios even explicitly, to ontological and epistemological positions. Researchers' differing ontological and epistemological positions often lead to different research approaches towards the same phenomenon (Grix, 2004).

Here follows more in depth explanations of different philosophies ontological Epistemological, and Axiological.

4.3.1. Ontological Theories

The dictionary defines Ontology as representing the metaphysical study of the nature of being and existence. Here the assumptions are the hypothesis or statements that are assumed as true and from which the conclusions are drawn. In ontological assumption, objectivism and subjectivism describe continuum polar opposites with differing philosophical positions aligned between them (Creswell, 2013). This enables a researcher to assert about what knowledge is and how it is being constructed (Creswell, 2013).

Since this research study process involves the complex interactions between organisations and its people (the main contractor, the sub-contractors, the consultants); and different organisational processes (product development, operations, lean and supply chains), the ontological stance of this research naturally leans towards constructivism because the understanding of the real world (in supply chains and processes) changes in each organisation and the knowledge is created socially Descartes (1641), Nonaka and Takuchi (1994), Peter Senge (1990) and Devenport (1994). The additional reason for choosing principle is that there can be multiple realities within organisations/participants which have different schools of thought on each construction supply chain and processes.

According to Mahoney and Rueschemeyer (2003) ontology is the part of the research that refers to the character of the industry as it actually is; and the epistemology is concerned with the nature and limits of the knowedge. Ontology has also been referred to as the philosophy concerned with the nature and form of what is known (Creswell, 2007).

4.3.2. Axiological Theories

World Wide Web Dictionary defines axiology as the study of values and value judgments. In a research philosophy, axiological assumptions define what value goes into the study (Creswell, 2013). Axiology looks at the value the researcher puts into the research (Saxton, 2003).

Some may argue that for this research study, the axiological stance could rest more towards value laden as the research may tend to solicit the opinions and experience of researchers to input into this research. This research analyses the different views of different scholars and establishes that the empirical research assumes that the tacit knowledge does not remain constant (Locke, 1823), (Devenport, 1994) and changes over the time. However, the view of Sir Francis Bacon (1557), Thomas Hobbes (1656) and Cartesian (Rene Descarte, 1644), and subsequent followers of the philosophy, contends that the creation of new knowledge is influenced by the experiences of an individual.

Therefore, equipped with that view, this research study assumes that findings would have some influence from the opinions and views of others and could not be completely value free.

As researcher, one presents bias while planning the research title, aim, objectives, methodology, survey questionnaire, interview questions, theory building, case study and conclusion writing and accept that social science research is bias free.

4.3.3. Epistemological Theories

The Websters dictionary defines epistemology as the study or a theory of the nature and grounds of knowledge, especially concerning its limits and validity; The encyclopaedia of philosophy defines epistemology as “the study of knowledge and justified belief; and the Oxford Dictionary defines it as the theory of knowledge, especially with regard to its methods, validity, and scope, and the distinction between justified belief and opinion.

In short, since there are many definitions of epistemology, the most predominant definition is the philosophical theory of knowledge.

Epistemology endeavours to answer the basic question: what distinguishes true (acceptable) knowledge from false (unacceptable) knowledge (Heylighen, 1993). Burrell & Morgan (1979) gave two different views of epistemology; these are Positivism and Anti-Positivism (Interpretivist). Positivists believe that researcher can seek to explain and predict what happens in the social world by searching for a pattern and relationship between them. Alternatively, the interpretivist thinking rejects the principle of positivism and argues that social science cannot create true objective knowledge of any kind. Interpretivist believes that reality is relative and various (Gettier). Therefore, based on this practice any research could have multiple realities whereas the positivist contends that there is only one reality. It is to be noted that the Knowledge created from the interpretivist hypothesis is comprehended by socially constructed and subjective interpretations (Greener, 2008; Creswell, 2013).

Therefore, the interpretivist paradigm of epistemology is the correct approach for this study since it assumes that the existence of multiple realities for this study that are socially constructed focuses on understanding behaviour rather than predicting it (Harrison & Reilly, 2011). In addition, the theory of Edmund Gettier (1963) had proposed that the different participant organisations have distinctive views, capabilities and needs concerning knowledge in supply chain and organisational processes. Based on this, the epistemological stance leans towards 'Interpretivist'. Some may argue that for this research studies that the building construction companies knowledge is socially constructed. The counter argument here could be that skill based technical as well as experimental knowledge also changes over time and could have multiple realities.

In short, the two different view at the either end of spectrum of social research are – posivitism and social constructivism (Saunders et. Al., 2007). Carter and Little (2007) had explained the term epistemology as the justification of the theory of knowledge whose methodology justifies the methods leading to the production of data and analyses.

Some researchers often define the bases of their research knowledge using the epistemological concept because it justifies the theory of knowledge whose methods leads to the production of data and analysis which is seemingly consistent with the opinions put forward by Carter and Little (2007), Figure 4.2.

The Epistomological questions involve concepts of knowledge, evidence, reasons for believing, justification, probability of what one ought to believe and any other concepts that can only be understood through one or more of the above list (Fumerton, 2005). Specifically speaking, the epistomology refers to what should be regarded as acceptable knowledge. This research study will need to investigate how management procedures, practices and processes lead to innovative practices in supply chain of the UK construction industry and therefore improve sustainbility. What are the key drivers behind that and how these drivers influence management decisions making most of them would not be objective variables and would be influenced by cultural, human factors and industrial practices. Additionally, it is feasible that some of the factors are either economic or objective.

For this research study ontology and epistemology positioning has an important impact on the researcher's thinking. Therefore, it has been observed that the definitions of these concepts clearly suggest that epistemology has a longer influence on both methods and methodology of any research. This thought is captured and illustrated in Figure 4.1.

Additionally, this argument is further supported by Easterby-Smith et al. (2008) who postulated that, the method a researcher employs during a research inquiry is justified by the epistemological assumptions adopted.

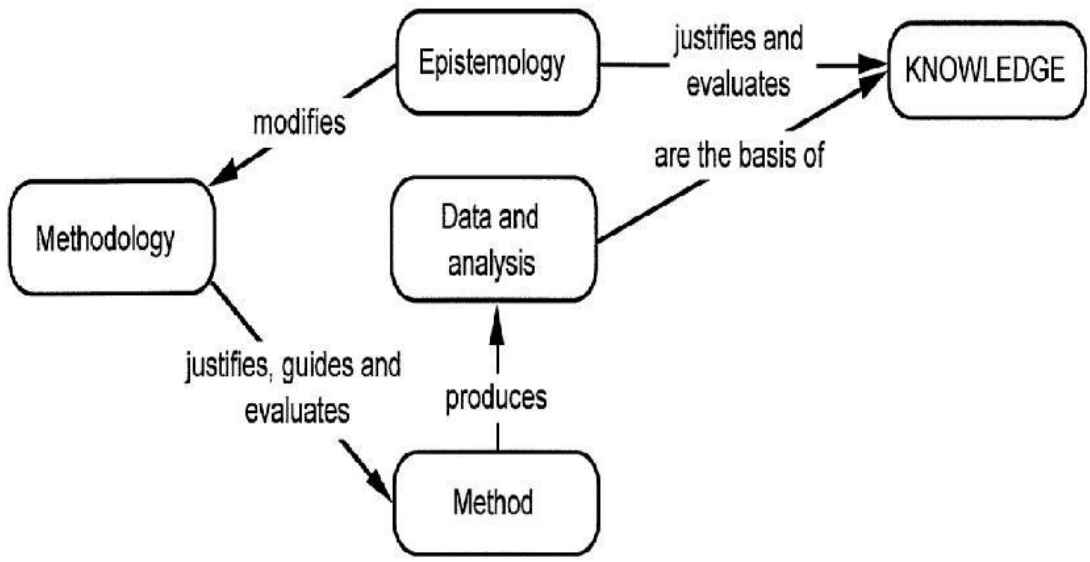


Figure 4.1 Relationships between Epistemology, methodology and method (Source: Carter and Little, 2007, pp. 1317).

Epistemological positioning ranges from *positivism* to *social constructivism* and in between is the *post-positivism* and *pragmatism paradigm* (Creswell, 2007).

Creswell (2007) further describe Positivism as a scientific research which is objective to reality, where the researcher engages in an impartial prior hypothetical testing, which is commonly associated with quantitative research methods. Moreover, Creswell (2007) described Social constructivism as a social research which is subjective in nature and context and commonly associated with qualitative research method, Post-positivism strikes a balance between the positivism and social constructivism; while its ideals are positivism its subjectivity is not absolute. Finally, Creswell (2007) had argued that pragmatism has no leaning to any of the elements above, rather its technique is based on what a research sought to achieve and is guided by specific research questions.

The positivist researcher is primarily concerned with quantifying a precise knowledge using scientific methods to present findings empirically (Henning et al, 2004). In the main, the positivist empirical assumption is to assess research subjects through theories and models that are based on facts and observations using quantitative methods (Henning et al, 2004; Veal, 2006; Ayikoru, 2009).

Nevertheless, whichever method applies with regards to the epistemological positioning of the researcher remains an interesting debate (Bryman, 1984; Steinzetz, 2004). While Polit and Beck (2008) argue that quantitative research is common with the natural sciences, Babbie (2007) on the other hand is of the opinion that social constructivism is more akin to social science researchers because it is subjective, based on how the researcher views an issue.

Johnson and Onwuegbuzie (2004) however, argued that these debates may be theoretical and argued that neither methods nor data collection are necessarily dependant on the epistemological belief and justification of the researcher. However, a later opinion suggested that these beliefs direct the research tasks and the choice of methods for a particular research (Creswell, 2009; Nightingale, 2011). Although, an earlier suggestion by Tashakkori and Teddlie (1998) had concluded that there is no absolute knowledge on the reality of nature and hence, concluded that the combination of both quantitative and qualitative methods reduces or closes the gaps in the absoluteness of knowledge. Therefore a pragmatic stance will be adopted for this thesis to direct the methodology and the choice of methods in order to address the research questions and achieve the overall aim of this research study.

4.4. Types of Research Techniques

In the main, a research approach is about organising research actions, including the data collection and the data presentation techniques in such a way that guarantees that they are most likely to achieve the aims (Keraminiyage, 2009). Saunders et al. (2009) had divided the research approach into two specific approaches, deductive and inductive. The difference between the two research approaches is that deductive is intended to test theory and inductive to build theory. The investigated phenomenon of transferring and sharing tacit knowledge within construction industry supply chain in relation to innovative practices or processes requires the proposed framework.

Therefore, it is more appropriate in a qualitative study to choose participants depending on whether they are 'information rich' and relevant to the research questions (Creswell, 2008; Bryman, 2004).

4.4.1. Qualitative and Quantitative

A qualitative approach to research is normally associated with an inductive method to generating theory, often using an interpretive model allowing the existence of multiple subjective perspectives and constructing knowledge rather than seeking to "find' it in 'reality" (Greener, 2008). It is based on the methodological principles of positivism and anti-positivism. This adheres to being standard for strict research design. It uses statistical analysis. A qualitative research with an interpretive model (anti-positivism) contends that there could be multiple realities of the investigated phenomenon.

Whereas a quantitative approach to research is associated with the deductive method to testing theory, often using a number of facts and, therefore, a positivist or natural science model, and an objectivist view of the objects studied is applied (Greener, 2008). This method aims to examine the social world. The key elements are exploration, relationship discovery, establishing a construct, and testing a hypothesis.

4.4.2. Qualitative and Quantitative reasoning

This study focuses on the innovative practices for the building products suppliers within the UK construction industry supply chain. This study employs both qualitative and quantitative research and a mixed method approach in obtaining data from respondents companies through in-person interviews and questionnaires. This study demands explanatory research to test the hypothesis and to explain the social relations and events in order to build a test and revise the theory. The use of an inductive approach in this manner is more suitable with quantitative research.

Originally, the literature was explored to identify the key variables to aid the selection of variables and therefore, develop the hypothesis and to develop the facts that support the hypothesis which fall into exploratory research and relate to the deductive approach with the arrangement of quantitative research.

4.4.3. Deductive and Inductive

The deductive approach is regularly used for theory testing and the inductive approach for theory building. Deduction is the dominant research mode in social sciences. In the deduction mode the basic principles present the basis of explanation and the foundation of investigation.

That is, the deductive research generally starts from exploring and establishing theories to finding the solutions to problems. Therefore, the deductive research necessitates the development of theoretical structure prior to engaging in empirical observation.

Robson (2002) presented five stages of deductive theories; this explains the way a deductive research conducts its stages.

- The researcher should deduce the hypothesis of the research from the literature review.
- To express the hypothesis in operational terms.
- Testing the operational term while adopting the research techniques which may consist of a variety of research methods, tools and techniques to validate the research operational hypothesis.
- To measure the outcome of a specific hypothesis to fulfil the research aim and objectives.
- To modify and build the theory as per the outcome of the data analysis.

However, the inductive process works in the opposite way to the deductive process, moving from specific explanations to broader generalisations and theories. Therefore, in the inductive approach, one begins with specific observations and measures. Subsequently, one detects patterns and regularities to help formulate some tentative hypotheses to explore. That is, one eventually ends up developing some general conclusions or theories.

Understandably, at the start this research study tilts towards the deductive process since it generates a hypothesis from theories and expresses these in operational terms. Later, it informs a framework to transfer tacit knowledge for building products suppliers in the UK construction industry supply chain practices in the context of innovative processes. Furthermore, this research proposes a conceptual framework and collects qualitative data to support the development process.

4.4.4. Deductive and Inductive Reasoning

In the main, a deductive approach begins by looking at theory and produces hypotheses from that theory (Robson, 2002). This may relate to the emphasis of the research and then proceeds to test that theory. However, this is not the only mechanism to use theory in a research study. An inductive approach starts by looking at the focus of research – the target company, a specific business problem, or a macro economic or social issue etc. - and through that enquiry by different research methods aim to create theory from the research (Greener 2008). In this study, initially the problems relating to the construction sector and the economic issues of the UK construction sector have been investigated to bring forward the problem statement for this research. Afterwards, different perspectives of innovation, supply chain and processes are examined from the theory with the aim of developing a conceptual framework while deducing a hypothesis, and expressing the hypothesis in operational terms.

4.5. Mixed Methods Research Methodology

Traditionally, research methods are basically qualitative and quantitative in nature (Onwuegbuzie and Leech, 2005). These are differentiated by the way data are collected, analysed and interpreted. Both methods are relevant and constantly used by researchers (Denzin and Lincoln 2000; Onwuegbuzie and Leech, 2005; Domegan and Fleming, 2007; Myers, 2009).

Qualitative methods explore and represent the interpretation of others with the aim of exploring issues of limited knowledge, which may be executed through, interviews or opinions, direct observations and documents which form data in words (Denzel and Lincoln 2005; Denzel and Lincoln 2006; Domegan and Fleming, 2007). In addition

Denzel and Lincoln (2005) and Saunders (2009) also agreed and suggested that qualitative methods are inductive in nature; which do not require hypothesis and the researcher is the instrument of data collection and analysis. A qualitative approach gives details of the behaviour of the study subjects (Brannen, 1992).

Likewise, quantitative research approach is considered an empirical research which is deductive in nature (Hinchney, 2008; Saunders, 2009) and mainly for statistical findings from questionnaire surveys and experiments as tools to gather the numerical data for the statistical analysis (Myers, 2009). Furthermore, Myers (2009) pointed out that quantitative research interprets opinions, compares, and highlights the trends of events and causality or reasons of the events with a focus on the particular number of population involved. Also, a quantitative research explores the attitudes rather than the behaviour of the research subjects in large-scale surveys (Brannen, 1992; Naoum, 1998) and includes experimental surveys and quasi-experiments (Social Justice Institute (SJI), 1999). Table4.1 compares these two approaches.

Approaches	Qualitative	Quantitative
Research philosophy	• Constructivist and Interpretative	• Positivist and rationalistic
Research Nature	• Inductive and Subjective	• Deductive • Experimental
Research purpose	• Towards understanding research subjects; • Gauge attitude, opinion and • establish trends	• To quantify a sample data in order to draw out the general views and opinion of the research interest
Research methods	• Flexible • Dependant on data collected for design • Hypothesis not required before research commences	• Fixed procedures are established before commencement of research • Hypothesis required before research commences
Sample size	• Usually small and to fulfil a given requirement	• Usually a large number of the population of research subjects and interest.
Data collection Methods (types)	• Observations • semi and unstructured interview • Focus groups • Case studies	• Structured interview • Questionnaires • Experiments • Content analysis / statistical analysis • Some case studies
Data analysis -	• Non-statistical	• Statistical • Descriptive
Research findings	• May be either Exploratory, investigative or both. • Inconclusive (context based) and may not be generalised.	• Conclusive and may be used for recommendation (universal context-based)
Researcher’s role	• Participatory	• Non participatory only an objective observer

Table 4.1 Differences between qualitative and quantitative research approaches

Generally, a qualitative research method gives in-depth and specify research findings while a quantitative research method provides a general understanding of the subject matter (Denzin and Lincoln 2005; Domegan and Fleming, 2007; Myers, 2009).

However, the selection of methods should be tailored towards reaching successful reflective findings that address the research questions (Patel, 2006).

A third research method that seeks to combine both methods discussed above has also been explored by researchers. According to Johnson et al. (2007) and Hart et al. (2009) the third method is known as the mixed-methods research. The mixed-methods seek to integrate the two approaches with the aim of achieving accurate and detailed information that offers a triangulation (Maxwell, 2005; Canales, 2012). Mixed-methods research captures holistically the reflection of an inquiry and trends both in depth and participants' opinions in general (Creswell and Clark, 2007). While, an earlier argument suggested that the mixed-methods allow for an analytical framework from literature review and investigative findings from individuals and groups (Brannen, 1992; McDougall and Beattice, 1998). These arguments suggest that the mixed methods offer a wider research inquiry from small to larger inquiries involving human subjects. Therefore, it was decided to adopt the mixed-research method for this research.

The mixed methods have been recognised to have eight stages explained in Figure 4.3 which articulates the processes involved at each stage. It commences at the initial stage of making a choice to the final stage of report writing. Even though the stages were numbered it has been observed that researchers do have multiple directional movement between stages 4 to 7 as shown in Figure 4.3 below.

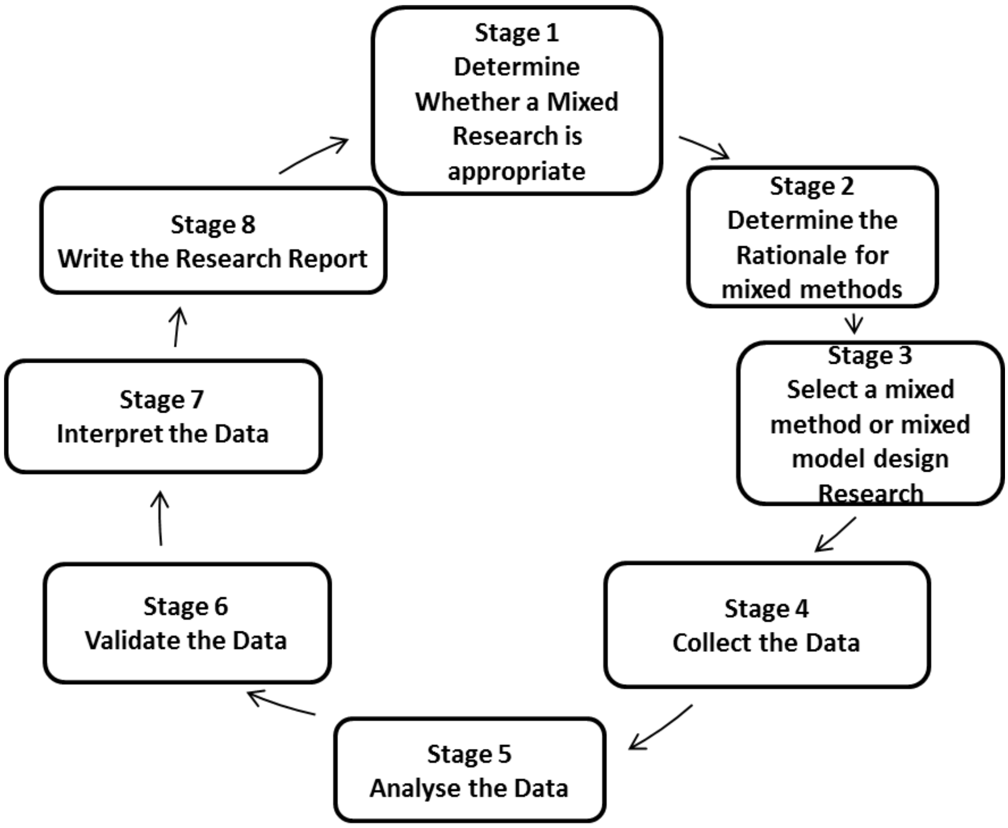


Figure 4.2 Stages in mixed methods research

4.6. Research Strategy

In the preceding sections the discussions on the research concepts, assumptions and the research approach has positioned this research project for a mixed methods research strategy.

The research strategy brings the focus to the research approach. A research strategy refers to the ways in which to conduct the research. A range of strategies are available. Saunders et al. (2009) argued that no research strategy is superior or inferior to any other. The research question and the objectives drive research strategy and are mutually exclusive. Saunders et al. (2009) and Denscombe (2007) gave strategies for social research namely, Surveys, Case studies, Experiments, Ethnography, Phenomenology, Grounded theory, mixed methods and Action research.

4.6.1. Rationale for Adopting Mixed Research Methods

The mixed-method research brings together diverse views, meanings and their relationships in different perspectives. Johnson et al. (2007) explained that the mixed methods of research is knowledge that integrates theories with practice as reflected by the quotation below

"Today, the primary philosophy of mixed research is that of pragmatism. Mixed methods research is, generally speaking, an approach to knowledge (theory and practice) that attempts to consider multiple viewpoints, perspectives, positions, and standpoints (always including the standpoints of qualitative and quantitative research)". (Johnson, Onwuebuzie and Turner, 2007 pp.113)

This research project adopts the mixed method for reasons relating to diverse research questions that a single method may not be able to address effectively. Additionally, a mixed method offers the research finding validation from different information sources (stakeholders, professionals and users). Triangulation enables the collection of information in any particular research from different sources and the individual research subjects, thus, varying opinion on supply chain innovation for sustainable construction industry will take advantages of triangulation.

The integration of qualitative and quantitative research provides a 'more accurate and comprehensive information' (Canales, 2012, pp.7). A quantitative approach checks the limitations of the qualitative approach and also the likely biasness in interpreting data as well as generalization of the research findings by the researcher (Creswell and Clark, 2007). Furthermore, the qualitative approach balances the researcher's subjective views along with those of smaller research groups (Creswell and Clark, 2007).

Furthermore, other advantages for mixed-methods includes accuracy, robust information that answers research questions as well as giving valuable knowledge to policy makers as well as educators, groups and individuals (Onwuebuzie and Leech, 2005; Hart et al, 2009; Canales, 2013). Furthermore, Asmar et al. (2012) in a study postulated mixed-research methods that could involve the participation of the stakeholder in the environment.

More importantly, is that the combination of methods allows for triangulation which generally gives a credible research outcome (Maxwell, 2005; Bryman and Bell, 2011). Table 4.2 highlights the rationale for adopting a mixed-method research adopted from Greene et al. (1987) and Bryman (2006).

The main reason for adopting the approach is because it uses quantitative scientific tools to drill down and crystallize on the subjective views of the researcher thereby sifting out any possible unverifiable data. The quest for a credible research underpinned by verifiable data makes the mixed-method a preferred and justified choice for this research project.

4.6.2. Types of Mixed Method Research Design

Four types of mixed methods design in research have been identified. These include; embedded, explanatory, exploratory and triangulation designs (Morse, 1991, Creswell et al, 2003; Creswell, 2006).

The embedded methodological design is a set of data that normally complement each other, whilst using different methods to address different research questions (Morse, 1991; Morgan, 1998Creswell, 2006).

Secondly, the explanatory methodological design operates in two phases, where the qualitative data plays an explanatory role to the quantitative findings; especially where findings are at variance and contrast with previous research conclusions (Creswell et al, 2003; Creswell, 2006; Creswell, 2009).

The third mixed method research is the exploratory methodological design, which explores different emerging concepts and theories, especially where the first method is qualitative and requires a second method which is quantitative to further explore emerging phenomena, test instrument or variables, and for generalizing group results (Creswell et al, 2003; Creswell, 2006).

Finally, the triangulation methodological design is the most commonly used mixed method research design; this is because it allows the researcher to use both quantitative and qualitative methods sequentially or concurrently to obtain complementary data in a single research project (Creswell, 2009).

4.6.3. Types of Triangulation Mixed Method

The triangulation mixed method is further divided into three research strategies.

Creswell (2009) grouped the concurrent mixed methods into concurrent embedded strategy, concurrent triangulation strategy and concurrent transformative strategy.

The study of Creswell (2009) further stressed that, even if all three strategies, that is, concurrent embedded, concurrent triangulation and concurrent transformative obtain quantitative and qualitative data, the concurrent embedded strategy would normally employ secondary data to support the primary data sources. This will add value to the total research as well as provide a wider perspective to the research findings. This research adopts the use of concurrent embedded strategy to ensure that the findings are explicitly detailed, robust, grounded and well understood.

Some other research methods not adopted for data collection are; focus group or group interviews and direct observations. The focus group or group interviews are usually prearranged meetings of the target participants together and are considered a substitute to interviews (Kmeger and Cassey, 2000). However, the prearranged meeting nature of the group interviews was not used because of difficulty in getting the target participants in one venue at the same time from different locations.

Secondly, high cost of moving these highly placed professionals, differences in their work schedules may prolong getting a suitable time for everyone and potentially high tendency for participants not to express their opinion in the open.

Conversely, observation is an approach that allows the researcher to observe and record information from people within or outside an environment, with or without their consent (Robson, 2002). Practically therefore, the observation method will not be effective enough for understanding the role, knowledge, perception and practices in the UK construction industry. Hence, due to lack of applicability to the true intentions and focus of this research, the methods mentioned above will not adopted.

4.7. Research Approach for This Study

For this research study we will begin by develping a theoretical framework using review of available literature. This model will be further refined and validated using surveys, interviews and case studies. Therefore, this research will be deductive where we will start with a model and further narrow it down using data.

Since the nature of this study is expected to be exploratory in nature (rather than conformatory), quantitative data collection method (survey) will be used. Initial literature review helps in identification of problem and development of conceptulla framework. Subsequently, detailed literature review will be used to develop a structured questionnaire. Data will be analysed using SPSS. Case studies will be done to validate the framework. For evaluation of innovative practices in the supply chain, a multi-criteria decision making technique will be used.

The final approach developed will include following stages:

- Questionnaire design and testing
- Sample selection
- Data colletion and sample characteristics
- Data analysis
- Case study and evaluation of organisation's innovative supply chain practices

4.8. Research Sample and Sampling method

A research involves people representing a targeted or a subset of a research population (Robson, 2002; Kelley et al, 2003) who are known as the research sample. The opinion of the targeted population is sought in order to gather the relevant information towards research findings (Bryman, 2004; Mugo, 2010).

The target population for this research are professionals in the UK construction industry. The target population will enable the researcher to understand what supply chain participants in the UK construction industry consider when adopting innovative supply chain practices.

An important aspect of a research is the sampling consideration. Sampling is a selection process that chooses a set or unit of a research population that help to produce a result that reflects a fair representation of the entire population being studied (Trochim, 2006). In the main, sampling is sub-divided into probability (random sampling) and non-probability (non-random) sampling (Trochim, 2006; Saunders et al, 2009), and each further divided into specific sampling units as shown in Table 4.3.

Source	Methods	Types	Character	Selection
Trochim, 2006; Saunders et al, 2009; Danika, 2010	Random or probability sampling (common with quantitative data collection)	Simple Random Sampling	Everyone has the chance of being selected	Purposive expert sampling was selected for both quantitative and qualitative data. However, Snowball sampling was adopted in some cases
		Stratified Random Sampling (proportional or quota)	A specific group of a subset is selected	
		Systematic Random Sampling	Selection is based on an equal interval of every nth element	
		Cluster or area Random sampling	Deals with very large samples e.g. national surveys	
		Multi-stage sampling	Used in studies that seek to obtain the maximised value of probabilistic sampling methods	
	Non-random or non-probability	Accidental, Haphazard or Convenience Sampling		
		Sampling -Modal Instance Sampling - Expert Sampling - Quota Sampling -Heterogeneity Sampling -Snowball Sampling		
		Convenience sampling		

Table 4.2 Examples of sampling methods (Source: Compiled by the researcher, 2013

In the study carried out by Onwuegbuzie and Collins (2007) titled ‘a topology of Mixed Methods Sampling Designs in Social Science Research’, they argued that, both random and non-random sampling can be used in quantitative and qualitative studies

(Onwuegbuzie and Collins 2007). Therefore, for this research study it was decided that it is most appropriate to use non-random purposive sampling methods, as this research is directed at specific UK construction industry professionals. A non-random sampling will be adopted for both surveys; expert sampling technique providing the quantitative data and for the qualitative data collection a snowballing technique will be employed.

Selected participants- the selection of participants was based on a careful match between the aim and objectives of this research and participants judged by the researcher to be in the right position to answer the research questions. Professional positions and years of experience were key considerations for the selection of potential interviewees. The following considerations determined the choice of participants:

- The individual participants are professional in the UK supply chain industry.
- Participants may also be academics, private or public practitioners.
- Participants recommended by other participant(s).
- Mainly participants who have understood the research aim and objectives and have given their consent to participate.

4.9. The Surveys

Quantitative research study survey is selected as an appropriate method for this study. This study requires the collection of data from multiple professionals from the UK construction industry to investigate their understanding to fulfil the objectives of this research study. It is believed that this approach will be more insightful, than relying alone on a case study method; since the case study method does not allow the encapsulation of the perceptions of these professionals.

4.9.1. Quantitative Survey

A pilot survey is undertaken on a randomly selected representation to draw out areas to be fine-tuned on the survey questions before the actual survey is undertaken. At the end of the pilot survey, some survey questions would be either dropped and / or restructured. Generally, it is acceptable that a pilot survey ensures validity of research processes because it helps researchers avoid potentially biased tendencies. Thus, a pilot survey is considered a desirable test before administering questions for questionnaires and interviews (Bryman and Bell, 2011).

The option for online survey and the use of postal services would also be considered. Thus, the researcher has considered physical administering of questionnaires as a more suitable option.

In the case of the face-to-face interviews, the initial interview questions would be administered to a number of interviewees, in order to know if the questions were easy to understand and conveyed their intentions. After this exercise a few questions is expected to be re-worded. It is also expected that completed questionnaires returned would help to provide adequate information and clarifications that would shape the final survey, which would further enhance the validity of the survey instruments employed. The questionnaire survey instrument is attached as **Appendix A.**

4.10. Qualitative Survey

An interview provides the avenue to gather information orally through the use of guided sets of questions. According to Saunders et al. (2009), interviews consist of structured, semi-structured and unstructured questions. In this research, structured questions are mainly utilised to ascertain innovative supply chain information (section A) from participants. However, semi-structured questions (section B) are used for the main interview. Semi-structured interview serves as a guide, allows the researcher to take advantage of its flexibility and to minimise omissions (Babbie, 2005; Teddie and Tashakkori, 2009).

The interview allows the measurement of their personal opinions on the interview questions in order to draw up appropriate recommendations at the end of the research. Additionally, the interviews would provide this thesis the opportunity to document data on the opinion of the UK construction industry.

A qualitative approach best suits the exploratory nature of this research and allows both the participants and researcher to draw from the experiences and the contextual peculiarity of limited documentation in the UK construction industry.

In an interview based qualitative research the sample size is usually smaller than those of quantitative research (Mason, 2010). Although there are situations where many participants are willing, it is better to engaged a focus group experienced with relevant experience who has been informed about the researcher's areas of inquiries and milestone to be achieved (Morse, 2000; Fossey et al, 2002; Adler and Adler, 2011).

However the exact sample size varies based on the assertion by Brannen and Nilsen (2011) that a sample size is dependent on the quality and logic of the study being carried out. A good sample size should be between twelve and sixty (12-60), which is demonstrated across similar research (Charmaz, 2006; Peak, 2010; Bryman, 2012). An adequate interview number should be from twelve (12) and above according to Guest et al. (2006).

This research therefore, adopts a 20 sample size as a way of giving a fair representation.

The interviews are conducted in industrial settings. For the purpose of accuracy, a recorder is used during interviews and at the same time, interview notes are also taken.

The researcher gets an added advantage by sending the interview questions to the interviewees ahead of the interview sessions.

4.11. Questionnaire Design and Testing

Here the survey questionnaire design is discussed and therefore, critically analysing each question and its variables.

In some ways this section presents and establishes the reasoning behind the design of each question by asking the questions listed here:

1. What is the purpose of asking the question and its variables?
2. What is the connection with the research objectives?

3. What is the connection of the question being asked with the literature review?
4. What type of data is to be collected?
5. What type of data analysis technique is to be adopted?

The study data used in this research consist of questionnaire responses from different managers in building products suppliers for the UK construction sector. After reviewing the literature a structured questionnaire was developed.

The questionnaire has been divided into parts, based on the research questions, to generalise the context-specific results to meet the objectives of this research.

The reason for dividing up the questionnaire is to consider each research objective and to get appropriate answers from the most relevant respondents.

The questionnaire contains a section on profile of the participants and then a section on identification of drivers and barriers to innovative supply chain practices in the sustainable construction industry in the UK. The cover letter accompanying the survey is included in the **Appendix A** at the end of the document.

The brief of the questionnaire is as follows:

1. A brief about the research purpose
2. The questions relating to demographic data of organisations
3. Questions relating to drivers and barriers to innovative practices in the supply chain
4. Questions relating to different innovative practices in the supply chain
5. Questions related to influence of innovative supply chain practices on organisational performance

4.12. The Variables and the Hypothesis

The variables are the initial outcomes from the literature review. These variables are verified after the interviews with the industry managers and resulting barriers and drivers' variables are used to develop hypothesis.

4.13. Scale of Measurement

This research adopts the Likert scale format for its measurements to present the opinions of participants in response to the questions in the questionnaire for easy understanding. The Likert scale is the summation of all selected preferences by participants (Vanek, 2012). Vanek (2007) and High (2013) further suggested that a Likert scale ranges between a minimum of three (3) to seven (7) points scale, which is used to measure opinions and experiences in a particular subject, with the aim of achieving a standardised and comparable results, while avoiding unnecessary complexities for the researcher. In this research four measurements were adopted 1- strongly disagree, 2- disagree, 3-agree, and 4- strongly agree. Allen and Seaman (2007) opined that using a four-measurement scale of this nature has an advantage of excluding the options of neutrality. Furthermore, Synodinos (2003) also assert that, any well-structured questionnaire should be explicit enough for participants to offer in-depth opinions rather than to opt for a '**no**' opinion option. The above arguments therefore informed the researcher's decision to opt for the four-point Likert scale as being suitable for this research.

4.14. Sample

In the UK, the construction industry is considered to be critical economic contributor – providing significant employment and contributing to overall GDP growth. However, the growth in industry has not been followed up by significant progress in taking note of innovative practices in the supply chain. According to a House Commons Briefing paper (Construction industry: statistics and policy, 2015), in 2014, the construction industry's output was £103 billion, 6.5% of the total economy. There were 2.1 million jobs in the construction industry in Q2 2015, 6.2% of the total.

Despite the global economic change, the UK will continue to develop several projects both in private and public sectors in the construction industry – housing, infrastructure, industrial and commercial.

4.14.1. Data Sources

Basically, surveys are conducted to gather specific research information from a subset of a population (Aday and Cornelius, 2006). Hence, data collection involving people is normally used in surveys due to its wide range of collection techniques and channels like self-completion questionnaires, internet, postal, telephone and personal contact (Bryman, 2004). There are three main techniques for collecting data from people which have five common attributes (Robson, 2002); these techniques have been enumerated along with their attributes in Table 4.4.

Technique	Technique sub-type	1.interacti on	2. No of responses	3. Data	4. Channel	5.Synchronizion
Survey	Self-completion questionnaire	Single	**1**	Quantitative, Qualitative.	Physical	Asynchronous
	Survey by Internet	Single	1	Quantitative, Qualitative.	Internet	Asynchronous
	Structured interview by telephone	Single	**1**	Quantitative, [Qualitative]	Telephone	Synchronous
	Survey by structured interview	Single	**1**	Survey by structured interview	Face-to-face	Synchronous
One-to-one interview	Face to Face Interview	Single	**1**	Qualitative [Quantitative]	Face-to-face	Synchronous
	Telephone interview	Multip le	**1**	Qualitative [Quantitative]	Telephone	Synchronous
	Internet interview	Multip le	**1**	Qualitative [Quantitative]	Internet	Asynchronous/ Synchronous
Group interview	Focus group	Multip le	**> 1**	Qualitative [Quantitative]	Face-to-face	Synchronous
	Group interview by Internet	Multip le	**> 1**	Qualitative [Quantitative]	Internet	Asynchronous/ Synchronous

Table 4.3Techniques for collecting data from people (Source: Robson (2002: pp.223)

The use of both secondary and primary data would be adopted in order to address the research questions and to validate the findings from the literature review. Secondary data would be based on the non-empirical research which includes; a critical review of literature that relates to the subject of this research which would serve as the background, trends on current, evidence. Such sources would include; books, research publications, journal articles, reports, reports and other internet research publications. The UK construction industry is considered to be the backbone of the economy and significant contributor to nation's productivity, employment and it strengthens other industrial sectors too.

The construction industry in the UK continues to evolve and this impacts the environment. As a result the government continues to monitor the industry and not scared of implementing environmentally friendly measures in the industry supply chain. Hence the innovation practices in the supply chain industry are selected as the subject of the study.

Considering the difficulties in obtaining the data, approach similar to Zhu et. Al. (2005) is adopted to collect data. Therefore, the data collection and questionnaire will be developed in three stages:

1. Pilot test – to to test and refine the questionnaires.
2. Convenience sampling – for data collection distribute the samples to industry events. And the organisations will represent different numbers of employees and include:
    a. The public sector
    b. The private sector
    c. International companies with multi-national sites

4.15. Data Collection

As discussed in chapter 3, this research study concentrates on the building products suppliers within the UK construction industry and nature of innovation in the supply chain.

It was important for this data collection in this research study to identify the appropriate organisations and secure survey respondents within the building products manufacturing segment.

4.16. Data Tools and Techniques

The survey questionnaire is designed to collect interval scale data through general questions. The rest of the questionnaire collects ordinal scale data. It is noted that, ordinal data brings non-parametric data analysis techniques into consideration. The data analysis tools and techniques discussed in this section are considered in this study to analyse data and to generalise the results.

The primary data will be collected through the survey questionnaires for the building products suppliers in the UK construction industry. This data will be analysed using SPSS software package. The different techniques may include:

4.16.1. Reliability of Data Collected

It goes without saying that the reliability requires consistency. It was Saunders et. al., (2009) who had stated, for a questionnaire or face-to-face interview to be valid, it must be reliable. Moreover, the reliability can be measured by considering these three questions (Easterby-Smith et al., (2008):

- Will the measures yield the same results on other occasions?
- Will similar observations be reached by other observations?
- Is there transparency in the sense made from the raw data?

Giving considerations to these three questions brings about high reliability. Robson (2002), points to there being four threats to reliability:

- Participant error
- Participant bias
- Researcher error
- Researcher bias

These threats named here may influence the responses from the respondents in a way the one does not want.

This research already recognises that the participant bias may pose as a threat for this research. That is, respondents undertaking the questionnaires may exaggerate the answers through their organisation bias by wanting to portray the company in positive light.

4.16.2. Data Analysis

Based on the literature review and the assumptions made on the basis of the nature of data being ordinal to non-parametric; the data analysing and testing procedure on SPSS is defined for this study.

4.16.3. Descriptive Statistics

Descriptive statistics are numerical and graphical methods used to summarize data and therefore bring forth the underlying information. The numerical methods include measures and central tendency and measures of variability. For this research study mean and standard deviation will be used as descriptive statistics. Mean or the average is the sum of the values of a variable divided by the number of observations. Standard deviation is the positive square root of variance. Variance is the sum of the squared deviation of each value from the mean divided by the number of observations.

4.16.4. Reliability and Validity

Reliability and validity are two important characteristics of a measurement procedure. Reliability refers to confidence we can place on the measuring instrument to give us the same numeric value when the measurement is repeated on the same object (Hair et al. 2006). Preferably, one way to ideally measure reliability is by the test-retest method. It is done by measuring the same object twice and correlating the results. If the measurement generates the same answer in repeated tests, it is reliable. However, establishing reliability through test-retest is practically very difficult. Once a subject has been put through some test, it will no longer remain neutral to the test.

Some of the commonly used techniques for assessing reliability include Cohen Kappa coefficient for categorical data and Cronbach's alpha for internal reliability of a set of questions (scales). In this research study, instrument reliability is checked by using Cronbach's alpha value for internal consistency.

4.16.5. Internal Consistency

Internal consistency estimates reliability by grouping questions in a questionnaire that measure the same concept. One common way of computing correlation values among the questions in the instruments is by using Cronbach's Alpha. In short, Cronbach's Alpha splits all the questions in the instrument every possible way and computes correlation values for them. Cronbach's Alpha is just like a correlation coefficient, the closer it is to one, the higher the reliability estimates of your instrument. The generally agreed upon lower limit for Cronbach's Alpha is .70, although it may decrease to .60 in exploratory research (Robinson et al. 1991). Cronbach's Alpha is a less conservative estimate of reliability than test/retest. The primary difference between test/retest and internal consistency estimates of reliability is that test/retest involves two administrations of the measurement instrument. The reliability of an instrument does not warranty its validity. Validity means that our measuring instrument actually measures the property it is supposed to measure. Validity is the extent to which a scale or set of measures accurately represents the concept of interest (Hair, et al. 2006).

4.16.6. Content Validity

Content validity of a measuring instrument (composite measurement scales) is the extent to which it provides adequate coverage of the investigative questions guiding the study (Hair, et al. 2006). The content validity can be ensured by discussing the research instrument with the academics as well as senior managers from industry. Construct validity is measured using factor analysis. Factor loading in excess of 0.5 represents convergent validity (Hair, et al. 2006). Construct Validity is the extent to which a set of measured items actually reflects the theoretical latent construct those items are designed to measure. Thus it deals with accuracy of measurement. Evidence of construct validity provides confidence that items measures taken from a sample represents the actual true score that exists in the population.

4.16.7. Convergent validity

The items that are indicators of a specific construct should converge or share a high proportion of variance in common, known as convergent validity. Several ways are available to estimate the relative amount of convergent validity among item measures. The size of the factor loading is one important consideration. In the case of high convergent validity, high loading on a factor would indicate that they converge on some common point.

At a minimum, all factor loadings should be statistically significant. A good rule of thumb is that standardised loading estimates should be .5 or higher, and ideally .7 or higher. The rationale behind this rule is that the square of a standardised factor loading represents how much variation in an item is explained by the latent construct. Thus a loading of 0.71 squared equals 0.5. It means, the factor is explaining half the variation in the item with other half being error variance (Hair, et al. 2006).

4.17. Kaiser-Mayer-Olkin test

It is a measure of sampling adequacy and its use represents the ratio of squared correlation between variables to the squared partial correlation between variables. Kaiser (1974) recommends accepting values greater than 0.5 barely acceptable. Values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are greater and values above 0.9 are superb (Hutcheson & Sofroniou, 1999).

4.18. Bartlett’s Test of Sphericity

It tests the null hypothesis that the original correlation matrix is an identity matrix which indicates that the factor model is appropriate.

4.19. Multiple Regression Analysis

Multiple regressions are a general statistical technique used to analyse the relationship between a single dependent variables and two more independent variables (Hair, et al. 2006). The objective of the multiple regression analysis is to predict changes in dependent variable in response to changes in independent variables. This objective is most often achieved through statistical rule of least squares. In this study hypothesis testing is done using multiple regression analysis. Various statistics used are explained below. Normal probability plots will be used to check that residuals are normally distributed. Residuals are the actual value of dependent variable minus the value predicted by the regression equation. The residual divided by an estimate of its standard deviation is known as standardised residual. One can obtain histograms of standardised residuals and normal probability plots comparing the distribution of standardised residuals to normal distribution.

R represents the correlation between the observed values and the predicted values (based on the regression equation obtained) of dependent variable. R Square (R^2) gives the proportion of variance in dependent variable accounted for by the set of independent variables chosen for the model. R^2 is used to find out how well the independent variables (IV) are able to predict the.

4.20. Coefficient of Determination R^2

It represents the percentage of variation in the outcome that can be explained by the model. However, the R^2 value tends to be a bit inflated when the number of IVs is more or when the number of cases is large. The adjusted R2 takes into account these things and gives more accurate information about the fitness of the model. Ideally, its value should be same or very close to R^2. The difference between the two explained that if the model were derived from population rather than a sample, it would account for change% less variance in the outcome.

The F values represent the ratio of the improvement in prediction that results from fitting the model relative to the inaccuracy that still exists in the model. A significant value means that the final model significantly improves our ability to predict the outcome variable.

4.21. Regression Coefficient β

Regression coefficient is a measure of how strongly each independent variable (also known as predictor variable) predicts the dependent variable (also known as criterion variable). It is the numerical value of the parameter estimate directly associated with an independent variable. There are two types of regression coefficients – unstandardized coefficients and standardised coefficients, also known as beta value. The unstandardized coefficients can be used in the equation as coefficient of different Independent Variables along with the constant term to predict the value of Dependent Variables. The standardised coefficient β is, however, measured in standard deviations. The test is used to examine whether this value is significantly different from Zero. If it is significant, mean the predictor makes a significant contribution in predicting the outcome.

Multicollinearity refers to a situation when two or more Independent Variables are highly correlated with each other. Multicollinearity causes inflation in the standard error of regression coefficients resulting in a reduction of their significance. Care should be taken in choosing the IVs such that they are not highly correlated with each other. A common measure of multi linearity is variance inflation factor (VIF) that provides an index of amount that the variance of each regression coefficient is increased relative to a situation in which all of predictor variables are uncorrelated. A VIF is calculated for each term in the regression equation, excluding the intercept. A commonly used rule of thumb is that any VIF of 10 or more provides evidence of serious multicollinearity involving the corresponding IV (Cohen et al. 2003).

Durbin Watson test for correlation between errors, it tests whether adjacent residuals are correlated. This test is important for testing whether the assumption of independent error is tenable. The test statistics can vary between 0 and 4 with a value of 2 meaning residuals are uncorrelated. A value greater than 2 indicates negative correlation between adjacent residuals whereas the value below 2 indicates positive correlation. The size of Durban Watson statistics depends on the number of predictor in the model and the number of observations (Field, 2009).

4.22. Expert Interview

Once the results for means test analysis are collected, some experts (minimum of ten) are interviewed to seek their views on the factors that have been formed after analyses for means testing. Additionally, some experts (minimum of three) are brought together for a brainstorming session and they assess the factors and suggest changes if they feel necessary. The three experts are chosen based on their experience in project management in the UK construction Industry.

The researcher ensures that these experts have dealt with the supply chain issues in the UK construction industry.

4.23. Case Study

The case study mentioned as a strategy for doing research involves an empirical investigation of a particular phenomenon within its real-life context, especially when the boundaries between phenomenon being studied and the context within which it is being studied are not clearly evident (Yin, 2003). This method of study is especially useful for trying to test or evaluate theoretical models by using them in real world / organisation situations and testing whether scientific theories and models actually work in the real life. Although the case study approach offers many advantages such as being dynamic and flexible, it also has some disadvantages in some aspects, such as the limitation in getting access into an organisation, being very time consuming and difficulty in understanding the events in a particular period without knowing what went on in the past (Collins & Hussey, 2003). Thus, in this research, multiple case study method is adopted to evaluate the proposed conceptual framework in the UK construction industry.

In the main, senior level manager with graduate level qualification and experience of (more than ten years) within the UK construction is selected.

4.24. Summary

This chapter has presented the research methodology adopted for this research project. Philosophical assumptions were explained - ontology, epistemology and axiology (Creswell 2007, Saunders et al. 2007; Scotland, 2012) and reasons given as to why this research rest towards a pragmatic stance, and the adoption of a mixed-methods approach which was supported by the rationale behind the selection. Notable is the fact that, although knowledge is attainable, it is not absolute and therefore, requires more than a single method of inquiry.

That is, this chapter critically analyses existing research methodological models to develop a robust research methodology for this study. Based on literature review this research study had developed a themes framework with an aim to help with choosing appropriate research methods to fulfil the objectives of this research. Therefore, the research strategies, survey questionnaire and semi-structured interviews, were selected to collect data from respondents.

Afterwards, data analysis tools and techniques were established to analyse the qualitative and quantitative data (Saunders et. al. 2009; Easterby-Smith et al. 2008; Robson 2002; Hair et al. 2006; Robinson et al. 1991; Kaiser 1974; Hutcheson and Sofroniou 1999).

Subsequently the data collection tools and techniques were discussed in-depth to identify the individuals within the organisation, the target companies and the questionnaire design and to establish the tools and techniques chosen for the data analysis.

In summary, this study established that no social science research is bias free through presentation of different types of researcher's bias that can influence research; a combination of quantitative and qualitative data collection is the most appropriate approach for this study inform the new conceptual framework through different dimensions; this study employed the deductive approach to investigate the literature and sustainability in the industry through supply chain and organisational processes.

This also brings forward the drivers and the barriers associated with the effective transfer and sharing of Tacit Knowledge.

The next chapter focuses on the number of responses received and on the data organisation and data analysis.

Chapter Five
Data Analysis

5.1. Overview

Following on from the exhaustive discussion in chapter four about the data analysis choices, methods and strategy, this chapter centres on the data analysis of the quantitative data gathered through survey questionnaire and qualitative data gathered through engagement with the industry professionals. For this analysis IBM Statistical Package for the Social Sciences (SPSS) qualitative data analysis software was used to analyse the data and run the tests such as Reliability (Cronbach's alpha), Descriptive (Frequencies) and Correlation Analysis.

Additional descriptive analysis was carried out on the survey responses and is presented in this chapter. That is, a descriptive tests to define the frequencies of the number of respondents and the respective preferences. The Likert scale data questionnaire had produced ordinal data and for each question and its variable Reliability, Frequency and Correlation Analysis.

Based on the discussion in the Chapter 4 each variable is analysed to test its hypothesis; and the correlation between the organisational, industrial and regulatory factors; the organisational practices; and the organisations performance.

5.2. Introduction to Survey

As stated in the earlier chapters, studying supply chain practices of building products manufacturers in the UK Construction Industry and identifying nature of innovation is important for the UK construction industry.

It was assumed and expected that the comprehensive survey would serve to provide additional information in identifying and defining key elements of innovative processes and practices for the building products manufacturers in the construction industry supply chain; identifying the key parameters, drivers and barriers in adopting innovative supply chain processes and/or practices within the UK construction industry; establishing the extent to which UK construction industry management practices; and organisational performances have contributed to the sustainability.

5.3. Research Questionnaire Design

An extensive literature review, researching the building products manufacturers and industry specific literature was accessed to aid the design of the survey questionnaire. A number of questionnaire as well as editions reviews were carried out before finalising the questions for the survey questionnaire.

The questionnaire had included a number of sections:

- The organisational background information including a number of generic questions about the individual completing the questions, the organisation, number of employees etc.
- Key elements of the innovative practices and/or processes.
- Key parameters, drivers and barriers in adopting the innovative supply chain processes and/or practices; impact on supply chain innovations.
- Management practices and organisational performances that have contributed to the UK construction industry within the last 10 years.

In the main, the questions used for the research study can be categorised in three groups:

- The company, industrial and regulatory including the drivers and the barrier.
- The organisational supply chain practices.
- The organisational performances.

5.4. Pilot Questionnaire

A pilot questionnaire was sent via email to 22 product manufacturers, industry champions and the construction industry product users. This list was selected from the industry databases and a final list was created after visiting the Construction industry exhibition and talking to some of the building products manufacturers and gaining some direct contact details.

However, after receiving only three replies from the initial email, all target participants were contacted via telephone and reminder emails and encouraged to respond to this request. Subsequently, more completed surveys were returned.

5.5. Main Questionnaire

The feedback from the pilot study survey responses were used to further modify the questionnaires. As part of the main survey, 215 questionnaires were sent out to the building products manufacturers and suppliers for the UK construction industry. Each questionnaire contained 179 questions. There were 61 completed responses received from the targeted companies which included wood construction, concrete and cement, steel and manufacturers of products including sustainable products as well as other industry specific materials. The survey also covered all part of the UK and any particular geographical preferences or a bias for any regions was deliberately avoided.

The respondents were asked to rate the questions listed in the questionnaire using a 5 point Likert scale, where scores of ‘1’ represent either a ‘never used, or ‘unimportant’; and a ‘5’ represents ‘always used’ or ‘extremely important’.

5.6. Data Analysis of the Questionnaires

This section of the chapter represents the statistical analysis of the completed survey responses to further examine the existing innovative practices and methods used by the manufacturers of the supply chain industry. It was expected that this initial data analysis would help validate the data and help inform the development of the conceptual framework for this work.

For the data analysis all 61 responses were used and no survey response was rejected. It was decided to group the data from Likert scale and analyse the results. To carry out the data analysis Statistical Package for the Social Sciences (SPSS) version 22.0, was used. For the data analysis the SPSS was considered due to its user friendliness, features and applications.

The overall data analysis approach is summarised in Figure 5.1.

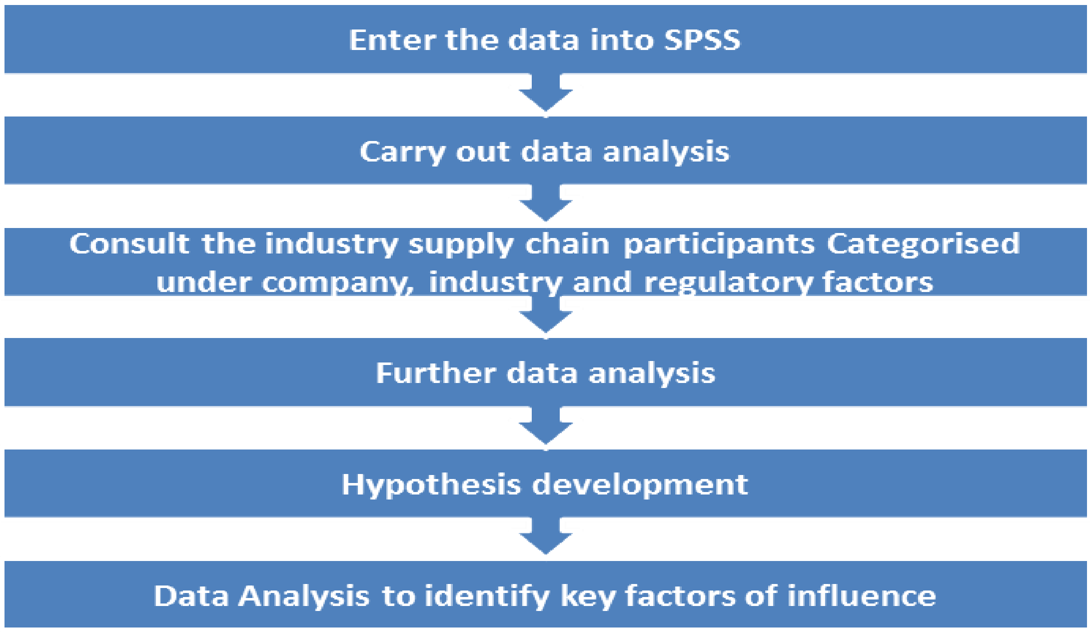


Figure 5.1 Data Analysis approach

5.7. Main Drivers Data from questionnaire

This section provides a statistical analysis of the main drivers behind innovative supply chain practices within the organisations received from the questionnaire respondents from the construction industry building products manufacturers.

The Table 5.1 presents the results of the descriptive analysis of the data for the key elements or drivers of the supply chain innovation from 5-point Likert scale. The data on these key elements has a range of 4; the mean is between 1.69 and 3.75; the standard deviation range is 0.671 to 1.433; and the variance range is 0.450 to 1.862.

This table (5.1) include descriptive statistic for each variable and the analyses N, which in this case is 61. It was especially important to check the analysis for N when faced with small sample, missing data or variables with lots of missing data.

A closer inspection of Table 5.1 reveals that the building product manufacturers in the UK construction industry consider the following 'too complex to adopt practices' as critically important factors within the organisation:

Drivers of supply chain innovation	N	Range	Min	Max	Sum	Mean	Std dev	Variance
Corporate social responsibility	61	4	1	5	229	3.75	.888	.789
Higher cost of disposal of waste material/products	61	4	1	5	229	3.75	.869	.755
Increasing scarcity of natural resources	61	4	1	5	216	3.54	.886	.786
Rising cost of utilities of energy	61	4	1	5	213	3.49	.887	.787
Cost reduction or profit motivated	61	3	2	5	209	3.43	.718	.515
Low returns of investments into supply chain innovation	61	4	1	5	209	3.43	.921	.849
Quality improvement	61	4	1	5	207	3.39	.971	.943
Customer pressure	61	4	1	5	199	3.26	.751	.563
Drive from the senior management	61	3	2	5	197	3.23	.716	.513
Regulatory pressure	61	4	1	5	191	3.13	.939	.883
Organisations supply chain mission	61	4	1	5	187	3.07	1.365	1.862
Enhanced organisational image	61	4	1	5	184	3.02	.671	.450
Improve organisational performance	61	4	1	5	183	3.00	.913	.833
Innovative practices too complex to adopt	61	4	1	5	183	3.00	.949	.900
Competitive advantage	61	4	1	5	180	2.95	1.087	1.181
Environmental partnerships with key suppliers leading to innovative practices	61	4	1	5	179	2.93	.873	.762
Target country supply chain regulations	61	4	1	5	177	2.90	.831	.690
Lack of management commitment	61	3	1	4	174	2.85	.727	.528
Price pressure driven by increasing competition	61	4	1	5	162	2.66	.929	.863
Higher cost of supply chain innovation initiative.	61	4	1	5	161	2.64	.967	.934
Poor awareness of buyers supply chain practice.	61	4	1	5	160	2.62	.897	.805
Incentives from customers and government	61	4	1	5	159	2.61	.862	.743
Global concern of Industry supply	61	4	1	5	155	2.54	1.433	2.052
Poor regional supply chain regulations for the industry	61	4	1	5	152	2.49	.788	.621
Industry specific barriers	61	4	1	5	152	2.49	.849	.721
Poor awareness of suppliers supply chain practices	61	4	1	5	150	2.46	.867	.752
Poor supplier commitments / or Unwilling to share information	61	4	1	5	147	2.41	.783	.613
Poor organisational supply chain standards or audits initiatives	61	4	1	5	145	2.38	.734	.539
Not organisations responsibility to adopt supply chain innovative practices	61	4	1	5	141	2.31	.886	.785
Lack of information / Lack of training about supply chain practices	61	4	1	5	141	2.31	1.285	1.651
Pressure of lobby group	61	3	1	4	127	2.08	.918	.843
Corrupt /bureaucratic environment	61	3	1	4	103	1.69	.743	.551

Table 5.1 Descriptive Analysis of main drivers and barriers

- Corporate social responsibility
- Higher cost of disposal of waste material/products
- Increasing scarcity of natural resources
- Rising cost of utilities of energy
- Cost reduction or profit motivated
- Low returns of investments into supply chain innovation
- Quality improvement
- Customer pressure
- Drive from the senior management
- Regulatory pressure
- Organisations supply chain mission
- Enhanced organisational image
- Improve organisational performance
- Innovative practices.

5.8. Reliability Analysis

For the main drivers of innovative supply chain practice for the building products manufacturers in the UK construction industry the data analysis gives a Cronbach's alpha value, 0.826 (Table 5.2). This value is more than the minimum Standard for reliability proposed by Santos (1999) and confirms that the measure is reliable for measuring the construct.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.826	.832	18

Table 5.2 Reliability Analysis of the Data

Cronbach’s alpha is most relevant in assessing the internal consistency of the survey since it includes multiple Likert-type scales and questions. In this section, through reliability analysis one was trying measure importance and relevance of the innovative supply chain drivers from manufacturers' perspective. After having entered the data in the SPSS, the reliability statistics table was provided. This table presents the Cronbach's alpha coefficient. The score for over .7 is considered to be good for internal consistency. That is, in this study the coefficient Figure (α = .826), shows that the questionnaire is reliable.

5.9. Correlations

The Table 5.3 below is part of a correlation matrix showing how each of the 18 drivers is associated with each of the other 17 drivers.

Note that some of the correlations are high (e.g., + or −0.70 or greater) and some are low (i.e., near zero). Relatively high correlations indicate that two items are associated and could possibly be grouped together by the means test analysis. Items with low correlations (e.g., ≤0.40) will not have high loadings on the same factor.

One assumption is that the determinant (located under the correlation matrix) should be more than .0001. Here, it is .001 so this assumption is met. If the determinant is zero, then a factor analytic solution cannot be obtained, because this would require dividing by zero, which would mean that at least one of the items can be understood as a linear combination of some set of the other items.

For instance, corporate social responsibility is strongly correlated to the rising cost of utilities of energy (0.727) and higher cost of disposal of waste material/products (0.772). Also, higher cost of disposal of waste material/products correlates with rising cost of utilities of energy (0.737). Increasing scarcity correlates with corporate social responsibility (0.750), in Table 5.3.

Correlation Matrix

		Regulatory pressure	Customer pressure	Improve organisational performance	Competitive advantage	Pressure of lobby group	Incentives from customers and government	Global concern of Industry supply	Quality improvement	Target country supply chain regulations	Enhanced organisational image	Environmental partnerships with key suppliers leading to innovative practices	Organisations supply chain mission	Drive from the senior management	Cost reduction or profit motivated	Rising cost of utilities of energy	Higher cost of disposal of waste material/products	Corporate social responsibility	Increasing scarcity of natural resources
Correlation	Regulatory pressure	1																	
	Customer pressure	0.218	1																
	Improve organisational performance	0.189	0.547	1															
	Competitive advantage	-0.109	0.26	0.25	1														
	Pressure of lobby group	0.03	-0.197	0.086	-0.046	1													
	Incentives from customers and government	-0.066	0.036	0.027	0.184	0.268	1												
	Global concern of Industry supply	0.126	0.124	0.297	-0.125	0.293	0.227	1											
	Quality improvement	0.059	0.197	0.31	0.196	-0.13	0.152	0.15	1										
	Target country supply chain regulations	0.101	0.123	0.362	0.105	0.494	0.247	0.402	0.319	1									
	Enhanced organisational image	0.29	0.091	0.228	-0.069	0.162	0.04	0.253	0.22	0.452	1								
	Environmental partnerships with key suppliers leading to innovative practices	0.261	0.034	0.438	0.029	0.241	-0.02	0.338	0.179	0.338	0.233	1							

	Organisations supply chain mission	0.151	0.178	0.337	0.189	0.224	0.221	0.463	0.232	0.388	0.217	0.401	1						
	Drive from the senior management	-0.166	0.319	0.358	0.092	0.078	0.152	0.149	-0.01	0.292	0.304	0.059	0.308	1					
	Cost reduction or profit motivated	-0.151	0.002	0.183	0.225	-0.17	0.254	0.119	0.375	0.101	0.193	0.086	0.329	0.323	1				
	Rising cost of utilities of energy	-0.19	-0.119	0.215	0.007	0.063	0.166	0.286	0.26	0.27	0.211	0.249	0.415	0.348	0.538	1			
	Higher cost of disposal of waste material/products	-0.277	0.122	0.232	0.125	0.02	0.323	0.244	0.251	0.153	0.179	0.108	0.353	0.304	0.433	0.737	1		
	Corporate social responsibility	-0.086	0.125	0.311	0.138	0.144	0.24	0.377	0.446	0.418	0.315	0.278	0.454	0.407	0.538	0.727	0.772	1	
	Increasing scarcity of natural resources	-0.103	0.127	0.29	0.199	0.122	0.058	0.187	0.307	0.358	0.243	0.22	0.35	0.325	0.385	0.645	0.669	0.75	1

a. Determinant = .000

Table 5.3 Correlation Matrix

5.10. Further Analysis

Additionally, all the responses received in the survey questionnaire were logged and some data analysis was carried out. This provided some additional understanding of the data received for the different practices; and this section provides additional information on this analysis.

5.10.1. Main Drivers behind Innovative Supply Chain Practice

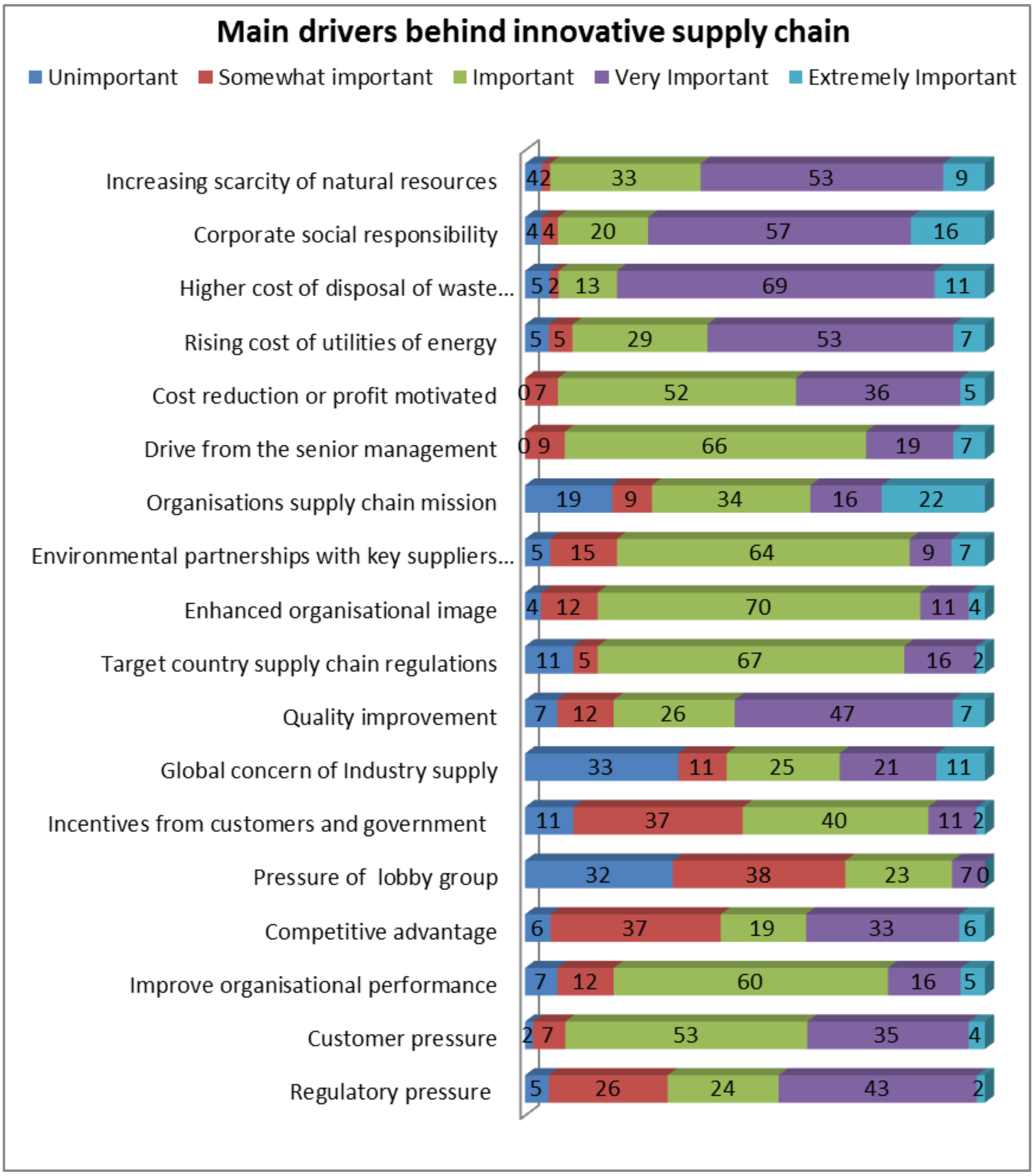


Figure 5.2 Main drivers behind innovative supply chain

The responses received for the main drivers of innovative supply chain 43% respondents believed that ‘regulatory pressure’ is very important; 53% respondents indicated that the customer pressure was somewhat important; and 37% respondents indicated that the ‘competitive advantage somewhat important’ (Figure 5.2.)

For ‘improve organisational performance’ (60% respondents); ‘target country supply chain regulations’ (67% respondents); ‘enhanced organisational image’ (70% respondents); ‘organisational supply chain mission’ (34% respondents); and ‘environmental partnerships with key suppliers leading to innovative practices’ (64% respondents) had indicated that it was important.

Amongst the questions considered very important were ‘increasing scarcity of natural resources’ (53% respondents), ‘corporate social responsibility’ (57% respondents), ‘higher cost of disposal of waste material/products’, (69 respondents), rising cost of utilities of energy’ (53% respondents) and ‘quality improvement (47% respondents).

The ‘pressure of lobby group’, (38% respondents) had consider it somewhat important, and ‘global concern of industry supply were unimportant’, (33% respondents).

The ‘incentives from customers and government were considered to be important’ by the survey respondents (40% respondents). The ‘drive from the senior management’ (66% respondents) and ‘cost reduction or profit motivated’ (52% respondents) were considered somewhat important.

5.10.2. Main Barriers in Adopting Innovative Supply Chain Practices

It was noted that a significant number of respondents had considered ‘lack of information/lack of training about supply chain practices’ (44% respondents); and ‘corrupt bureaucratic environment’ (58% respondents) as unimportant.

Amongst the factor considered somewhat important were ‘poor regional supply chain regulations for the industry’ (45% respondents); ‘poor organisational supply chain standards or audits initiatives’ (52% respondents); ‘poor awareness of suppliers supply chain practices’ (58% respondents); ‘industry specific barriers’ (61% respondents); ‘poor supplier commitments / or unwilling to share information’ (65% respondents);

‘higher cost of supply chain innovation initiatives’ (57% respondents); and ‘not organisations responsibility to adopt supply chain innovative practices’ (52% respondents).

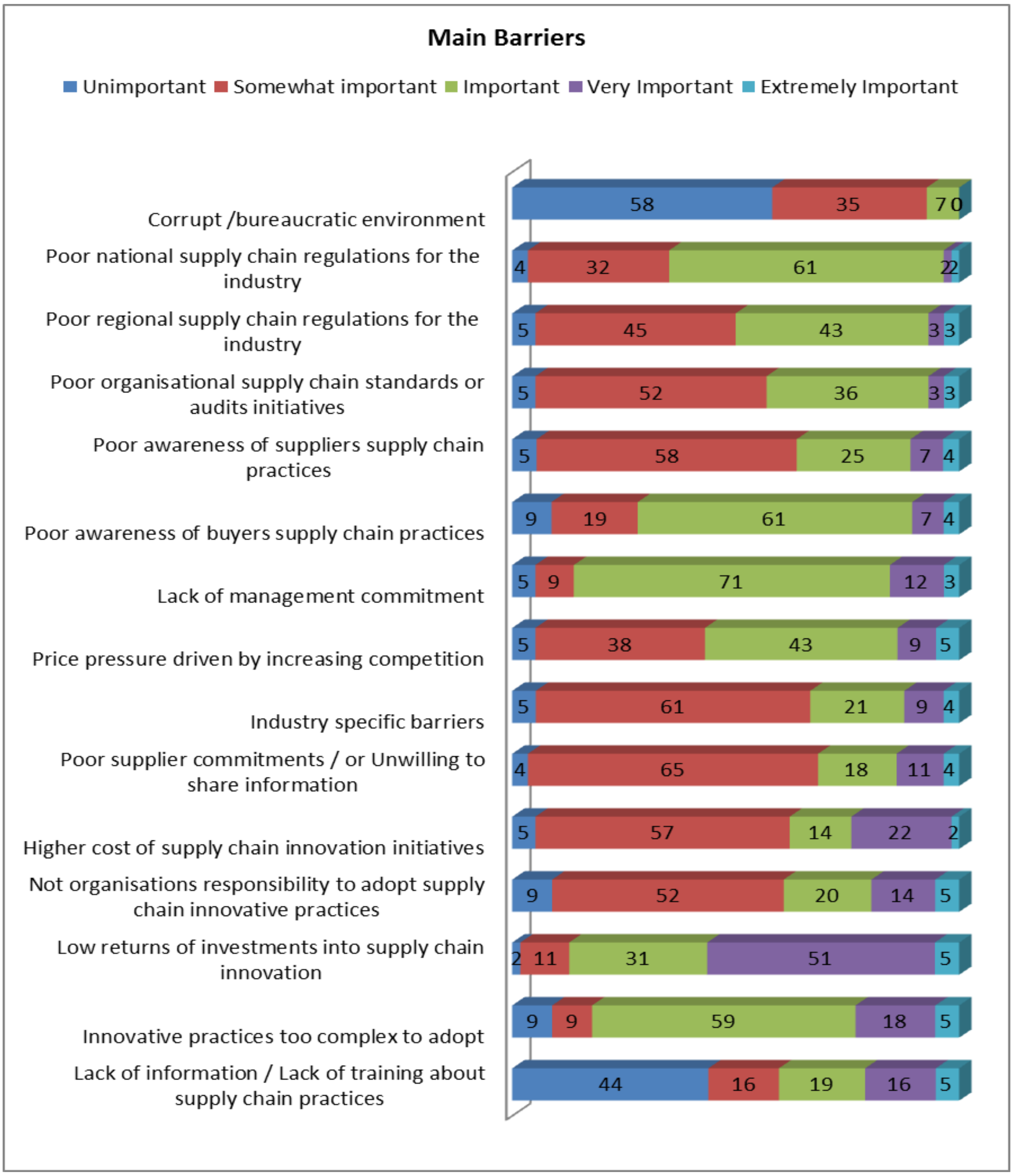


Figure 5.3 Main barriers in adopting innovative supply chain practices

The elements considered important were ‘innovative practices too complex to adopt’ (59% respondents); ‘price pressure driven by increasing competition’ (43%

respondents); lack of management commitment (71% respondents); and 'poor awareness of buyers supply chain practices' (61% respondents).

The question of low returns of investments into supply chain innovation' (51% respondents) was considered very important (Figure 5.3).

5.10.3. Impact of Economic Environment on Product Innovation

For this section of questionnaire, all respondents had indicated that 'country environment affects the type of product innovation in the company' (37% respondents); 'diversity in external environment impacts product innovation' (61%% respondents); 'technological environment impacts product innovation' (54% respondents); 'continue product innovation in uncertain and changing environment' (53% respondents); 'product innovation dynamism driven by external environment' (52% respondents) the factors were sometimes used, Figure 5.4.

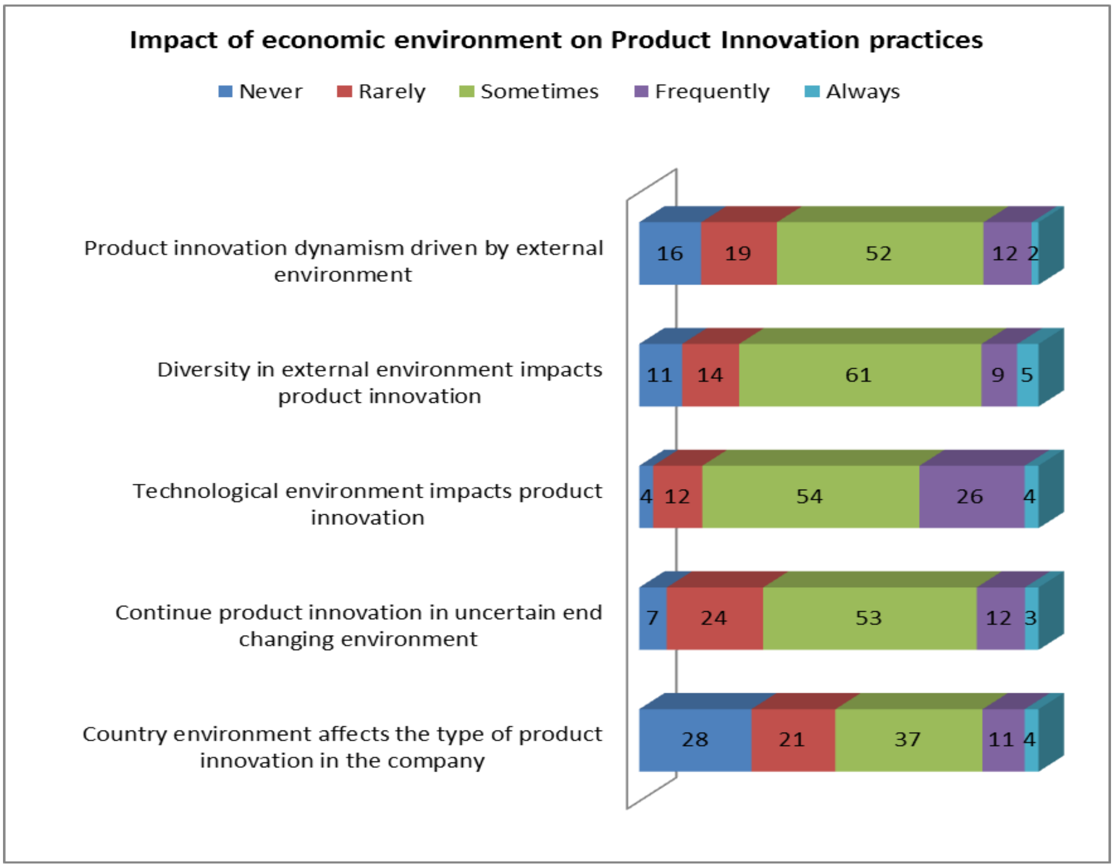


Figure 5.4 Impact of economic environment on product innovation practices

5.10.4. Impact of Organisational Processes and Management Practices on Supply Chain

It is noted that for question on 'impact of board or senior management diversity on product innovation' (72% respondents) rarely use.

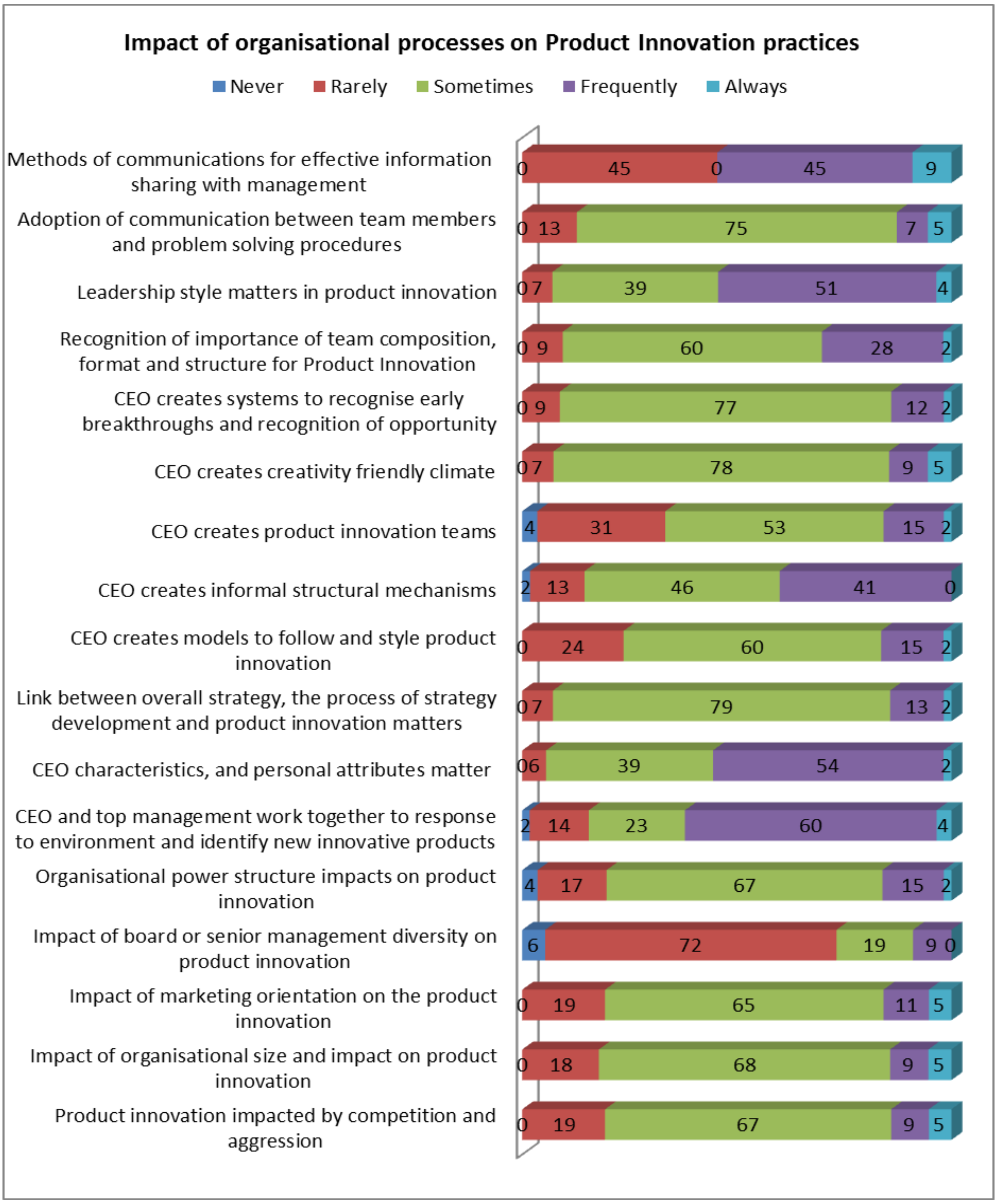


Figure 5.5 Impact of organisational processes on product innovation practices

For this section of the questionnaire the respondents had indicated that the factors frequently used were 'methods of communications for effective information sharing with management', (45% respondents). Amongst the factors sometimes used were 'link between overall strategy the process of strategy development and product innovation matters' (79% respondents); 'product innovation impacted by competition and aggression' (67% respondents); 'impact of organisational size and 'impact on product innovation' (68% respondents); 'impact of marketing orientation on the product innovation' (65% respondents); 'organisational power structure impacts on product innovation' (67% respondents); 'CEO creates models to follow and style product innovation' (60% respondents); 'CEO creates informal structural mechanisms' (46% respondents); 'CEO creates product innovation teams' (53% respondents), 'CEO creates creativity friendly climate' (78% respondents); 'CEO creates systems to recognise early breakthroughs and recognition of opportunity' (77% respondents); 'recognition of importance of team composition, format and structure for Product Innovation' (60% respondents); and 'adoption of communication between team members and problem solving procedures' (75% respondents).

It is to be noted that '45% respondents had also said that 'methods of communications for effective information sharing with management, were rarely used (Figure 5.5).

'Leadership style matters in product innovation' (51% respondents), 'CEO characteristics personal attributes matter' (54% respondents), and 'CEO and top management work together to respond to environment and identify new innovative products' (60% respondents) are factors which were considered as impacting frequently.

5.10.5. Key Elements of Innovative Supply Chain Practices

In order to gain a better understanding of the key elements of the innovative practices in organisations, the surveyed responses provided some interesting feedback. This analysis of innovative practices in the supply chain was linked directly to objective one of the research. This objective required identification and definition of the key elements of innovative processes and/or practices within the UK construction industry supply chain.

While analysing the data from the questionnaires it was observed that the responses provided evidence of significant recognitions and awards for the innovative supply chain practices amongst the building products manufacturers in the UK construction industry. It was observed that the 'use of lifecycle analysis to measure the innovation within the products and packaging was used. About 43% respondents had said that they frequently used; whilst 37% respondents had said, 'sometimes used'.

For the question on 'ensuring suppliers commit to reduce waste by adopting innovations', 44% respondents indicated that this was used frequently. For the question on 'participating in the design of products for recycling or reuse' 46% respondents had stated that this practice was sometimes used. For the responses to question about 'participating in the design of products for packaging' (72% respondent) and 'sharing technical expertise with suppliers adopting Innovative practices' (74% respondents) had said that it was sometimes used. Likewise for 'choice of suppliers by innovative supply chain practices criteria majority' respondents said that it was sometimes used (61% respondents).

However, when asked about 'bringing together suppliers in the industry to share their expertise and problems' (43% respondents) had indicated that it was either never used. Similarly, for 'organising workshops / seminars for suppliers on innovative supply chain practices' (33% respondents) had replied that it was rarely used; and 66% respondents had indicated that 'evaluating suppliers supply chain' was a frequently adopted practice.

'Encouraging suppliers to have ISO14001 certification' (34% respondents) and 'auditing suppliers to evaluate their environmental performance' (50% respondents) were considered to be frequently used practices (Figure 5.6).

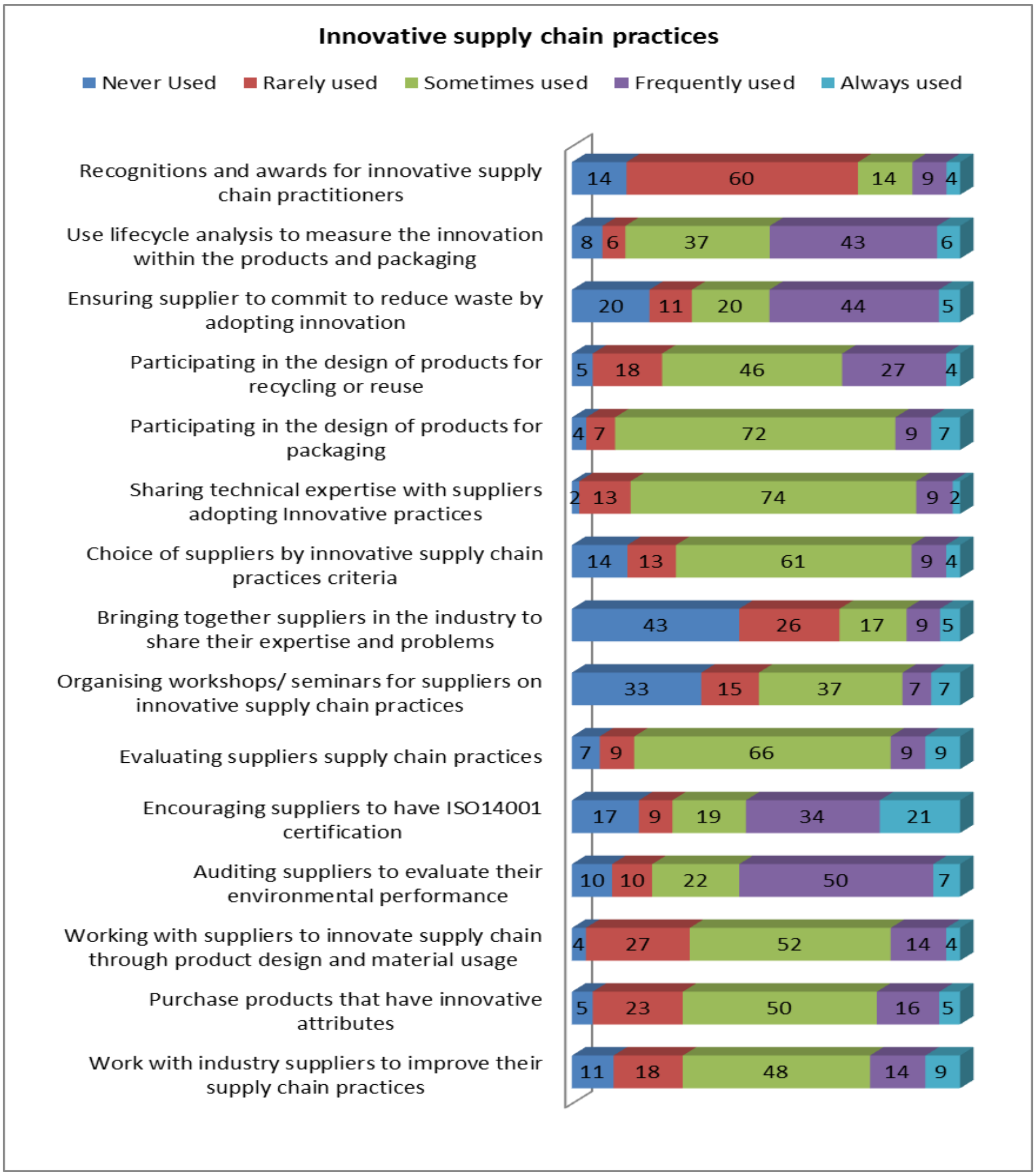


Figure 5.6 Innovative supply chain practices

For ‘working with suppliers to innovate supply chain through product design and material usage’ (52% respondents); ‘purchase products that have innovative attributes’ (50% respondents); and ‘work with industry suppliers to improve their supply chain practice’ (48% respondents) were considered to be frequently used practices.

5.10.6. Innovative Product Design Practices

In response to 'adopting new material for products' 55% of the respondents had indicated that the practice is used sometimes (Figure 5.7).

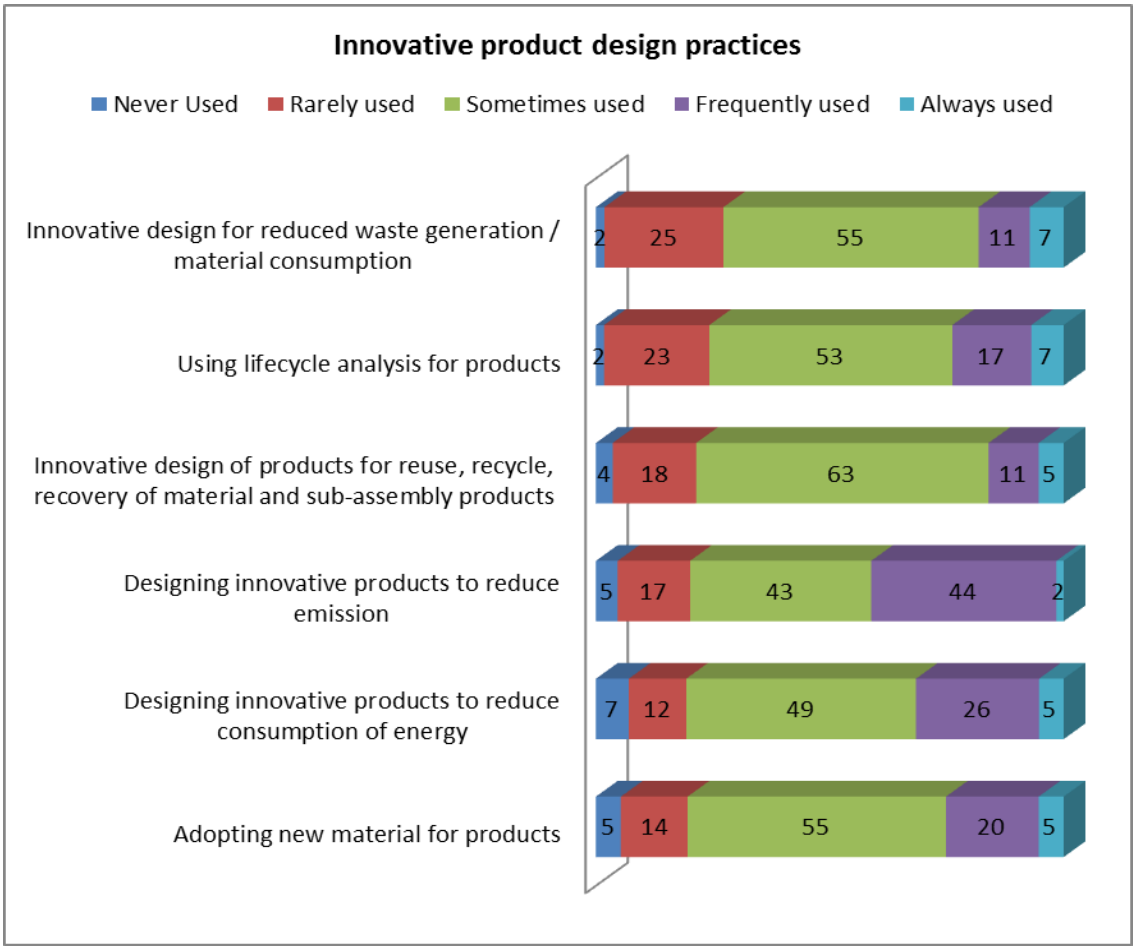


Figure 5.7 Innovative product design practices

Similarly, for 'designing innovative products to reduce consumption of energy' (49% respondents), 'designing innovative products to reduce emission' (43% respondents), 'innovative design of products for reuse, recycle, recovery of material and sub-assembly products' (63% respondents), 'using lifecycle analysis for products' (53% respondents) and 'innovative design for reduced waste generation/material consumption' (55% respondents) had indicated that these practices were sometimes used.

5.10.7. Lean Application and Adoption in design and product / materials development process

While considering whether the ‘design is informed by extensive data on performance of products, systems and components’ 58% respondents considered this somewhat important. For 57% respondents ‘carry-over to new models of a high proportion of systems and components from previous model’, it was important. Additionally, 72% respondents indicated that it was important that ‘value management to achieve more understanding and focus on client value’. The ‘use of visualization techniques such as virtual reality and 3D CAD to fully define the product requirements from the customer’s perspective’ 65% respondents; 69% respondents ‘concurrent working between manufacturer and supplier during design development’; and ‘front-loading of resources towards design to prevent problems during manufacturing’ 59% respondents, had all considered this as an important factors (Figure 5.8).

The ‘use of integrated design and build arrangements – such as partnering – to encourage close cooperation between designers, constructors and specialist suppliers’ was considered to be extremely important by 40% respondents; the ‘design for standardization and pre-assembly processes and product components to achieve higher quality, cost and time savings’, was considered important by 52% respondents.

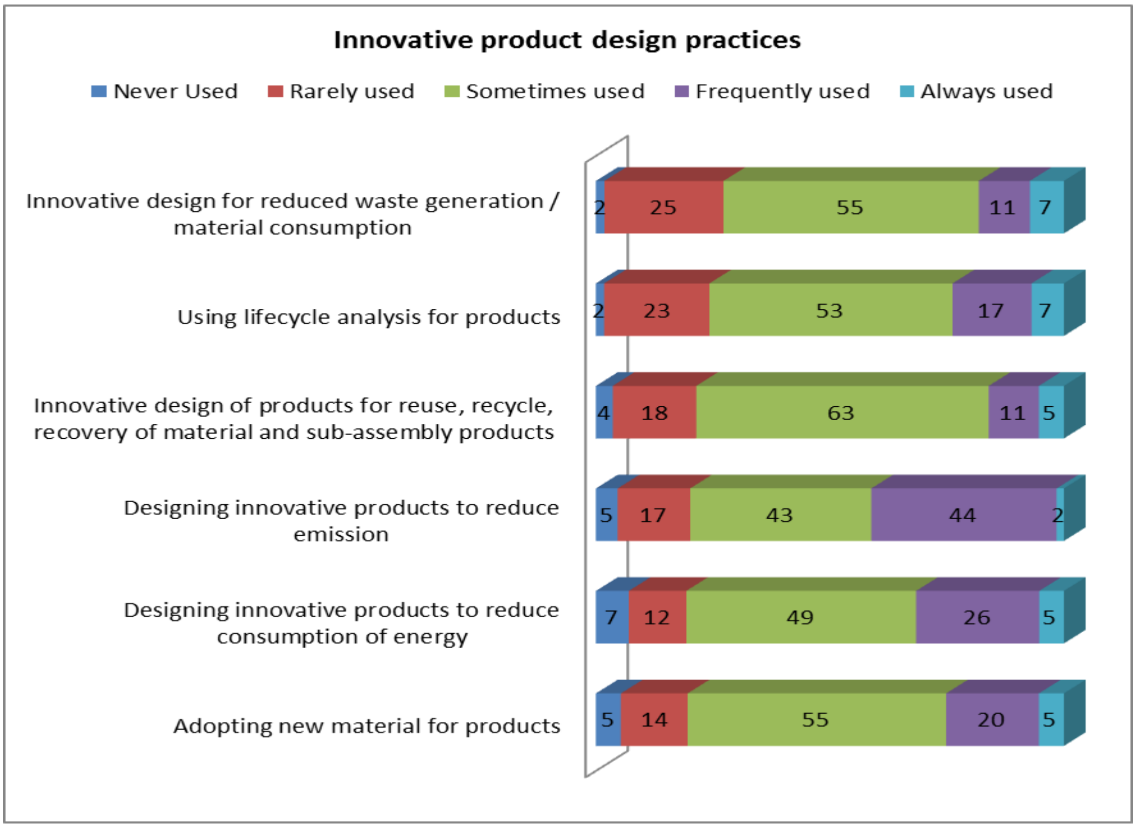


Figure 5.8 Lean application and adoption in design and product/materials development process

5.10.8. Innovative Products Production/Operations Practices

While considering responses for the products innovation/operations practices, 'modify production/operation processes to reduce supply chain solid waste' 48% respondents had said it was never used. For 'modify production/operation processes to reduce supply chain liquid waste' 74% respondents had said that it was rarely used. For modifying production/operation processes to reduce carbon emission 40% respondents said, 'it is never used'. It is notable that for 'interdepartmental cooperation for innovative improvements in the supply chain' a significant number of 52% respondents had indicated that they are rarely used. Yet, 'use innovative cleaner technology to save energy, waste etc.' (62% respondents); and 'recycle organisational supply chain waste' (64% respondents) had said that these were sometimes used.

In response to question about, 'production and operational planning and control focused on reducing waste optimising innovative materials exploitation', 44% respondents had indicated that it is frequently used (Figure 5.9).

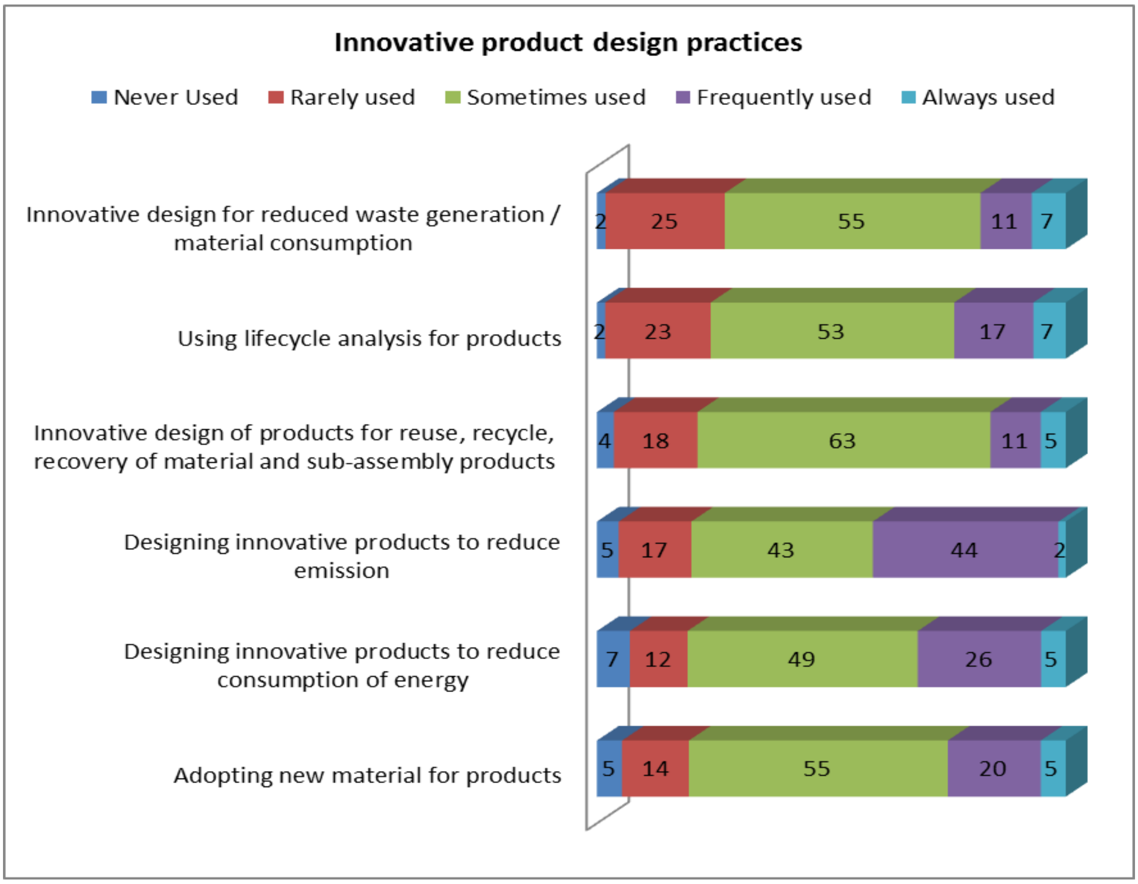


Figure 5.9 Innovative Products Production/operations Practices

5.10.9. Customer Engagement

For customer engagement, the following factors were considered important, 'data on customer satisfaction are disseminated at all levels in this business unit on a regular basis' (75% respondents); 'we are more customers focused than our competitors' (45% respondents); 'we have routine or regular measures of customer service (64% respondents); 'our business objectives are driven primarily by customer satisfaction (71% respondents); and 'we constantly monitor our level of commitment and orientation to serving customer needs (64% respondents).

Amongst the factors considered very important were 'We freely communicate information about our successful and unsuccessful customer experiences across all business functions' (70% respondents); 'we believe this business exists primarily to serve customers' (54% respondents); and 'we poll end user's at least once a year to assess the quality of our products and services' (58% respondents).

The factor 'we measure customer satisfaction systematically and frequently' 39% respondents had said that it was somewhat important.

The response considered to be extremely important was 'our strategy for competitive advantage is based on our understanding of customers' needs' (64% respondents), Figure 5.10.

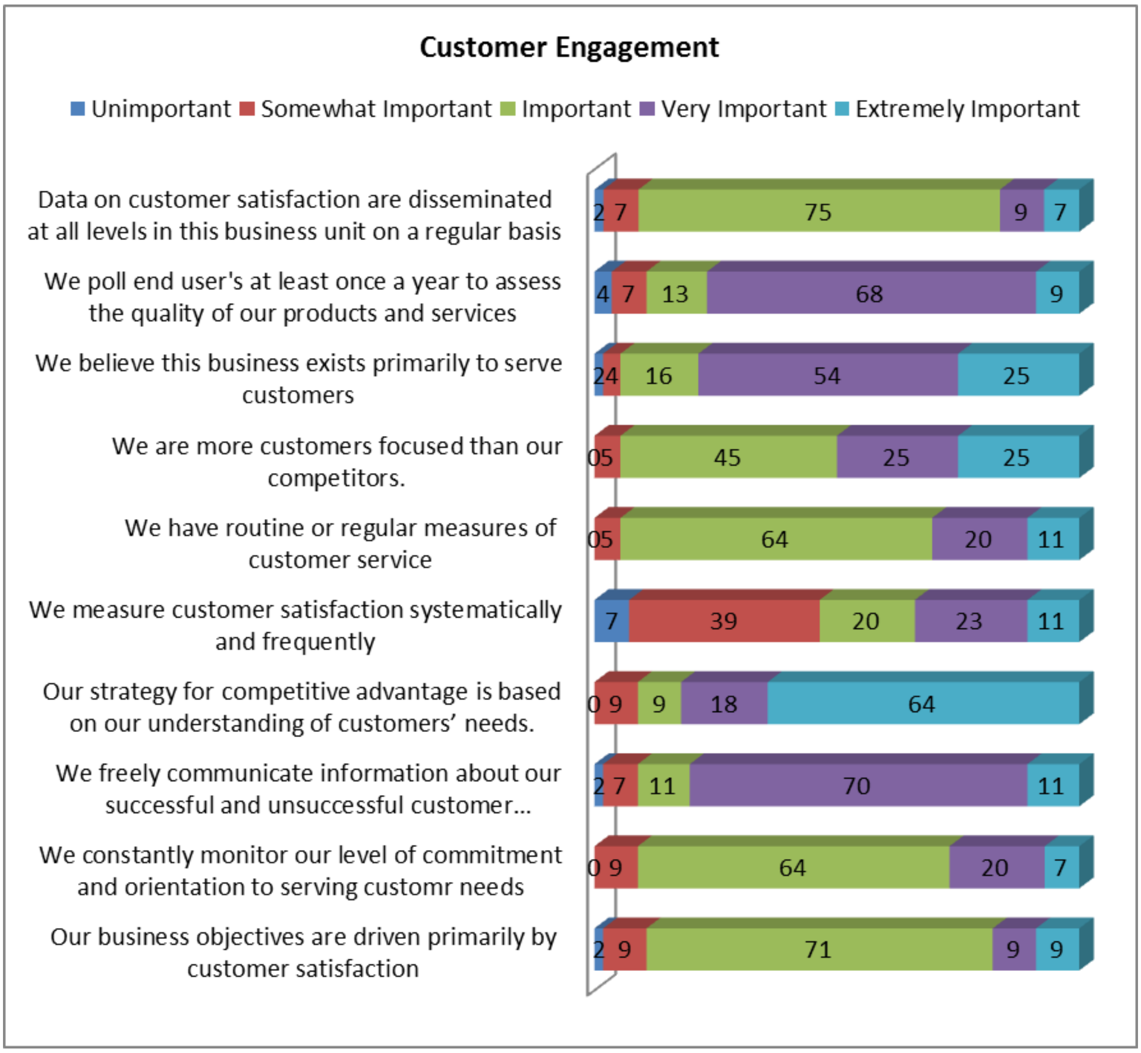


Figure 5.10 Customer Engagement

5.10.10. Innovative Supply Chain Management Practices

For innovative supply chain management practices questions, 'ISO14001 certification' had mixed response in that while 28% respondents had indicated that it was never used; another 28% had said it was always used (Figure 5.11).

The 'interdepartmental cooperation for supply chain improvements' 37% respondents had said that it was sometimes used and 40% respondents had said it was frequently used.

The factors sometimes used were 'supply chain compliance and auditing programmes' (67% respondents); 'supply chain policy' (53% respondents); 'supply chain training and awareness programme for employees (51% respondents); 'disclosure or sharing of supply chain practices records (65% respondents); 'rewards and incentives for the employees demonstrating innovative supply chain ideas/initiatives (59% respondents); and 'commitment from the top management for innovative practices in the supply chain' (64% respondents).

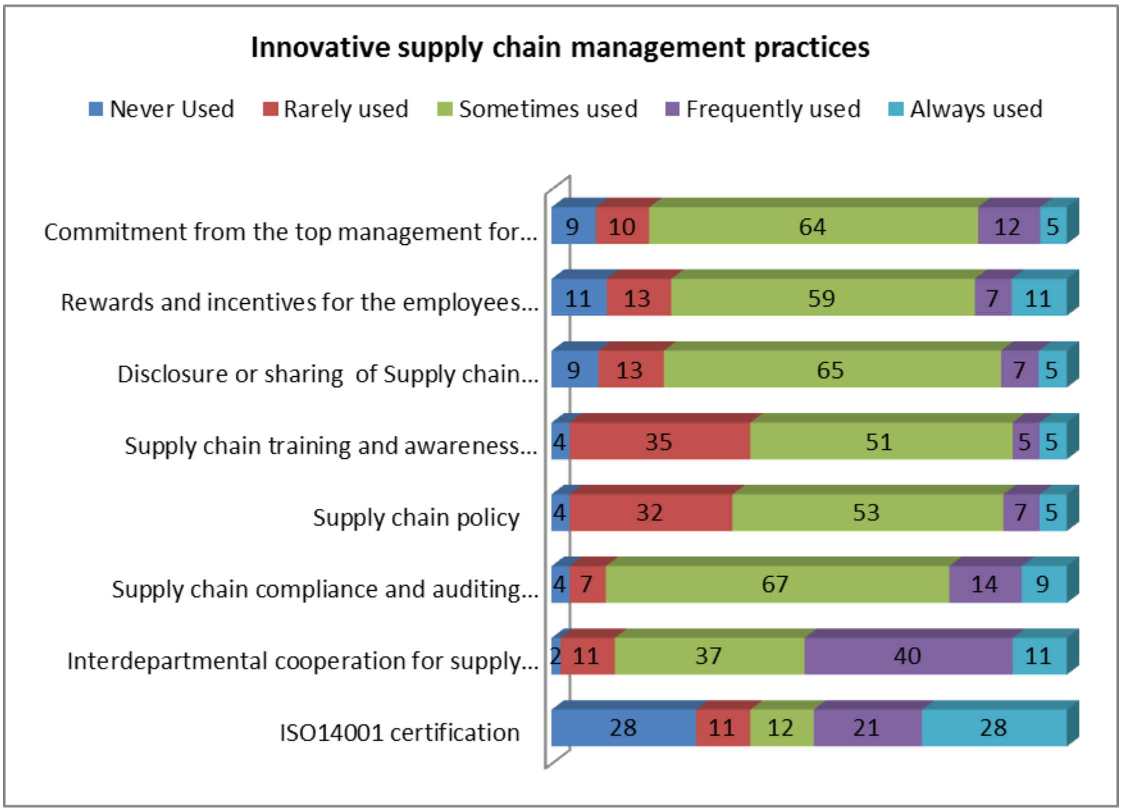


Figure 5.11 Innovative supply chain management practices

5.10.11. Innovative Marketing

For the marketing measure, 'eco-labelling products' 48% respondents had indicated that it is frequently used.

For the 'recovery of company's end of life products' 59% respondents had indicated that it is sometimes used (Figure 5.12).

Amongst the rarely used methods were 'using innovative packaging (56% respondents); 'recollecting the packaging' (47% respondents); and 'purchase recycled packaging' (50% respondents).

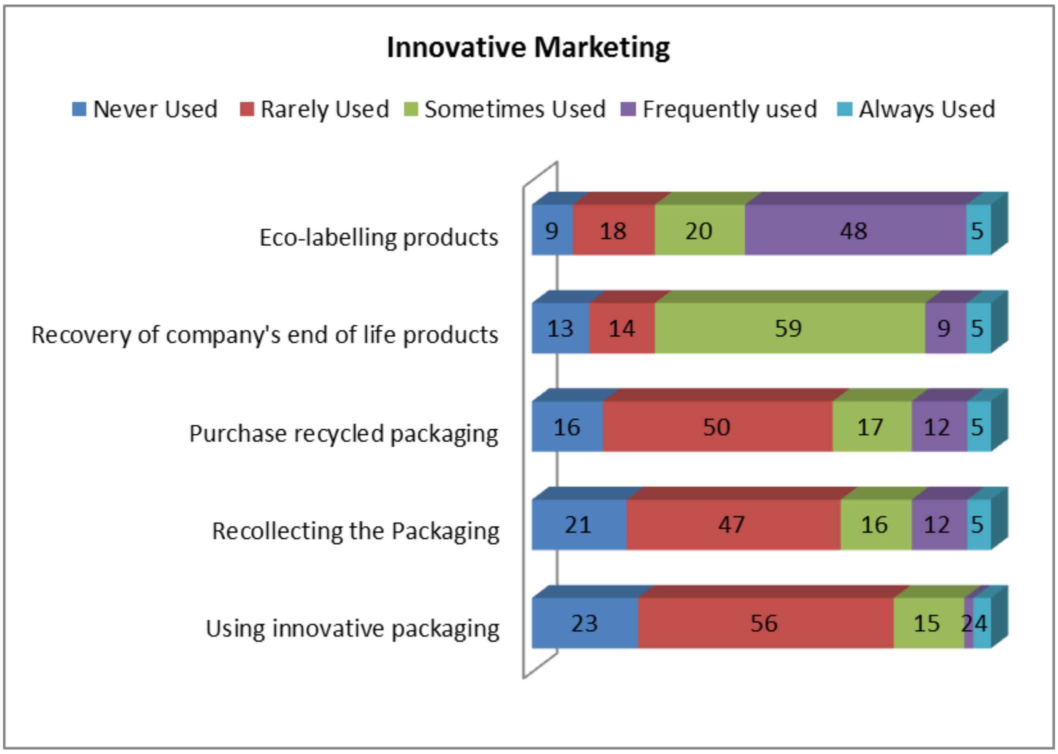


Figure 5.12 Innovative Marketing

5.10.12. Performance Measures

For this section the factors considered very important were 'increased profit margins as a result of innovative supply chain practices' (47% respondents); 'cost reduction as a result of innovative supply chain practices' (64% respondents); and 'reduction in waste through innovative supply chain practices' (49% respondents).

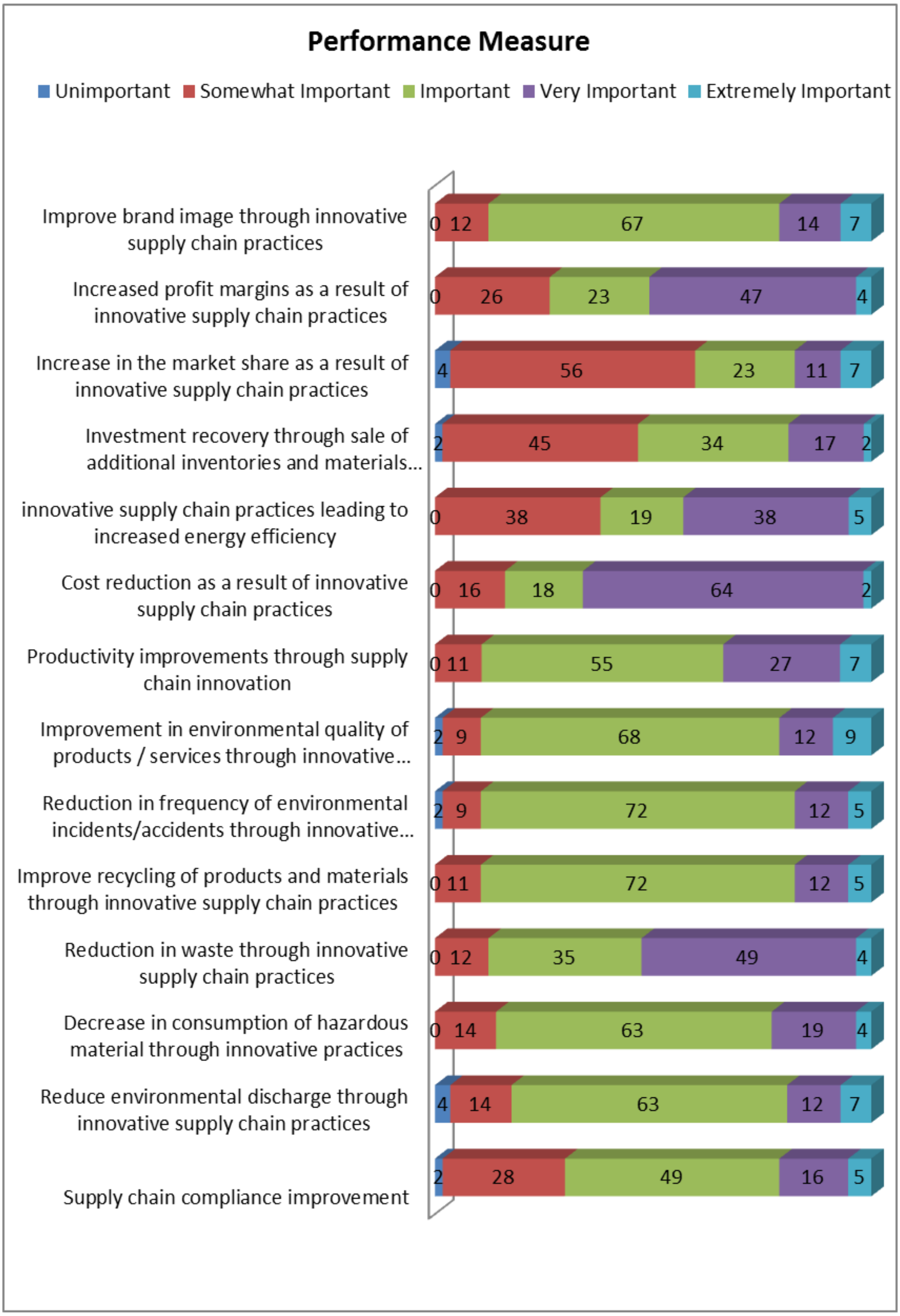


Figure 5.13 Performance Measure

For the factor ‘innovative supply chain practices leading to increased energy efficiency’ while 38% respondents had said that it is unimportant; in contrast, 38% respondents had replied that it is very important.

The responses considered unimportant were ‘increase in the market share as a result of innovative supply chain practices’ (56% respondents); and ‘investment recovery through sale of additional inventories and materials through innovation in supply chain’ (45% respondents).

The responses considered important were ‘productivity improvements through supply chain innovation’ (55% respondents); ‘improvement in environmental quality of products / services through innovative supply chain practices’ (68% respondents); ‘reduction in frequency of environmental incidents/accidents through innovative supply chain practices’ (72% respondents); ‘supply chain compliance improvement’ (49% responses); ‘reduce environmental discharge through innovative supply chain practices’ (63% respondents); ‘improve recycling of products and materials through innovative supply chain practices (72% respondents); and ‘decrease in consumption of hazardous material through innovative practices’ (63% respondents), Figure 5.13.

5.10.13. Innovative Supply Chain Logistics

In terms of innovative supply chain logistics section, 67% respondents had indicated that the ‘the development of close relations with first tier suppliers’ is always used and 68% had respondents said that there is a lack of reliance on formal contracts. For ‘innovative supply chain consolidation’ 63% respondents said it is rarely used, Figure 5.14.

The sometimes used factors were ‘use of reverse logistics’ (61% respondents); ‘using nearby supply chain sources’ (75% respondents); ‘using innovative supply chain friendly transportation’ (67% respondents); ‘using nearby supply chain sources’ (75% respondents); ‘use of standardised reusable containers / packaging in innovative supply chain logistics practices’ (74% respondents); ‘the use of benchmarking of suppliers’ performance against each other on a range of generic criteria’ (74%

respondents); and 'just-in-time delivery of materials to the point of eliminating the need for on-site storage and double-handling' (68% respondents).

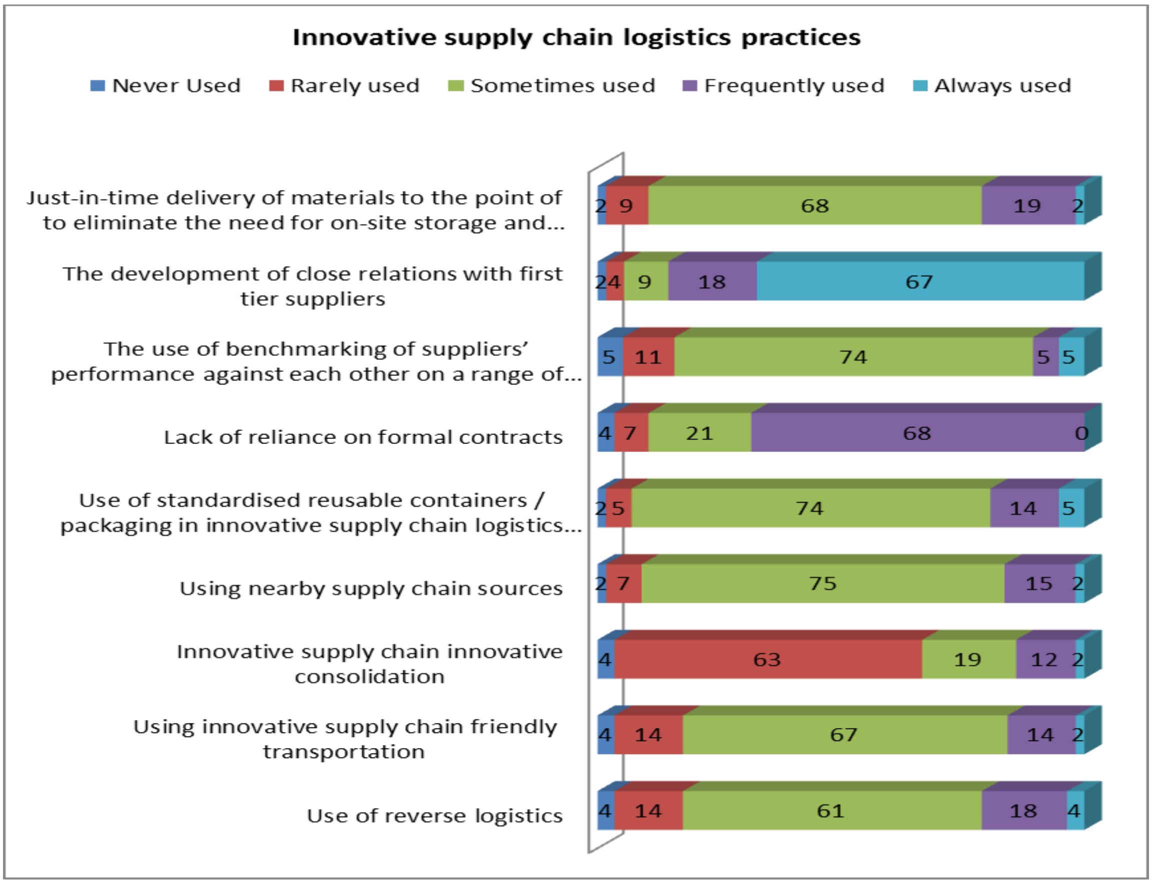


Figure 5.14 Innovative supply chain logistics practices

5.10.14. Semi-Automated Equipment Adoption

Where it concerns semi-automated equipment adoption, 40% respondents had considered 'semi-automated equipment improves safety by allowing workers to stay out of danger zone' as unimportant, Figure 5.15.

The factors 'semi-automated equipment provides higher quality by reducing workmanship errors and higher accuracy' (54% respondents); and 'semi-automated equipment improves productivity due to shorter delivery times' (42% respondents) were considered very important.

It was noted that 40% respondents considered 'semi-automated equipment reduces construction costs' as somewhat important.

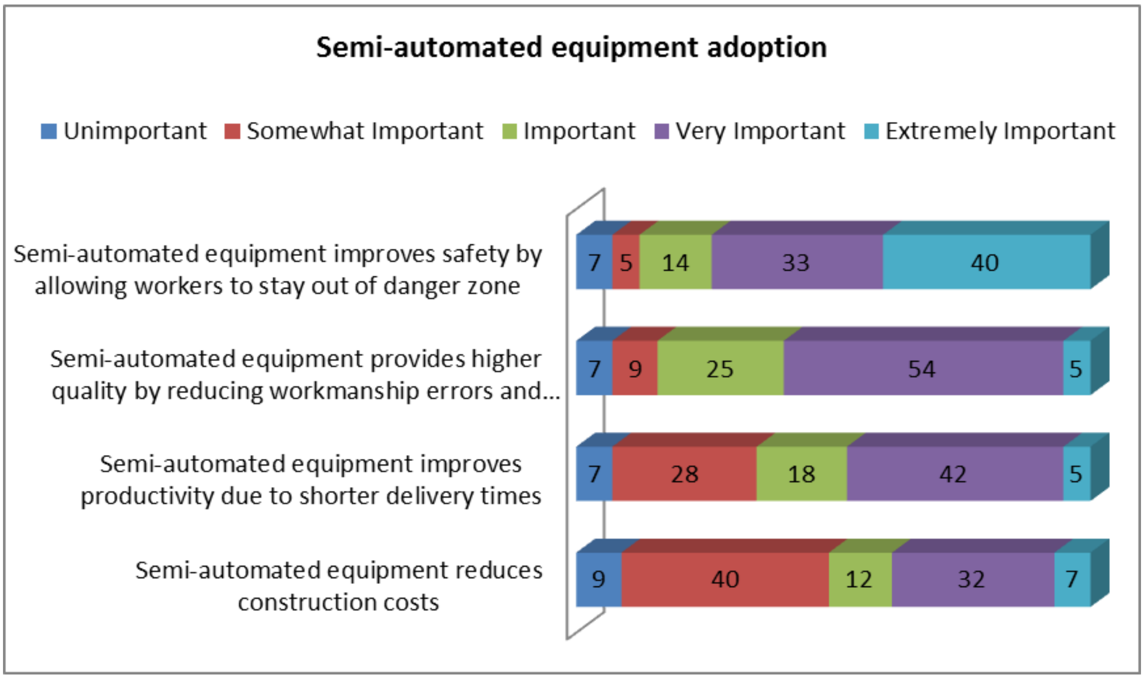


Figure 5.15 Semi-automated equipment adoption

5.10.15. Lean Adoption and Application in Supply Chain

Where it concerns Lean production practices, 'clear communication and project plans' (58% respondents), 'training, teamwork and multitasking' (62% respondents), 'daily progress reporting and improvement meetings' (65% respondents), 'pre-fabricated assembly improves quality control and reduced time on site' (68% respondents), 'pre-fabricated assembly reduces need for storage on-site of equipment, disruptions, labour costs, noise and waste' (64% respondents), 'resource efficient and improves control of costs and site productivity' (67% respondents) and 'reduced environmental impact through reduced wastage in manufacturing and on-site' (74% respondents).

Some respondents indicated that 'using dedicated design teams working exclusively on one design from beginning to end and developing a tool to significantly speed up design process' is somewhat important (53% respondents).

The factors considered important are, 'improves control of supply chain, reliably and continuous improvements through feedback loops' (57% respondents), 'supporting sub-contractors in developing tools for improving processes' (53% respondents), 'innovating in design and assembly through the use of fabricated brick infill panels manufactured off site and pre-assembled roofs lifted in to place' (55% respondents) and 'improving the flow of work on site by defining units of production and using tools such as visual control of processes' (68% respondents), Figure 5.16.

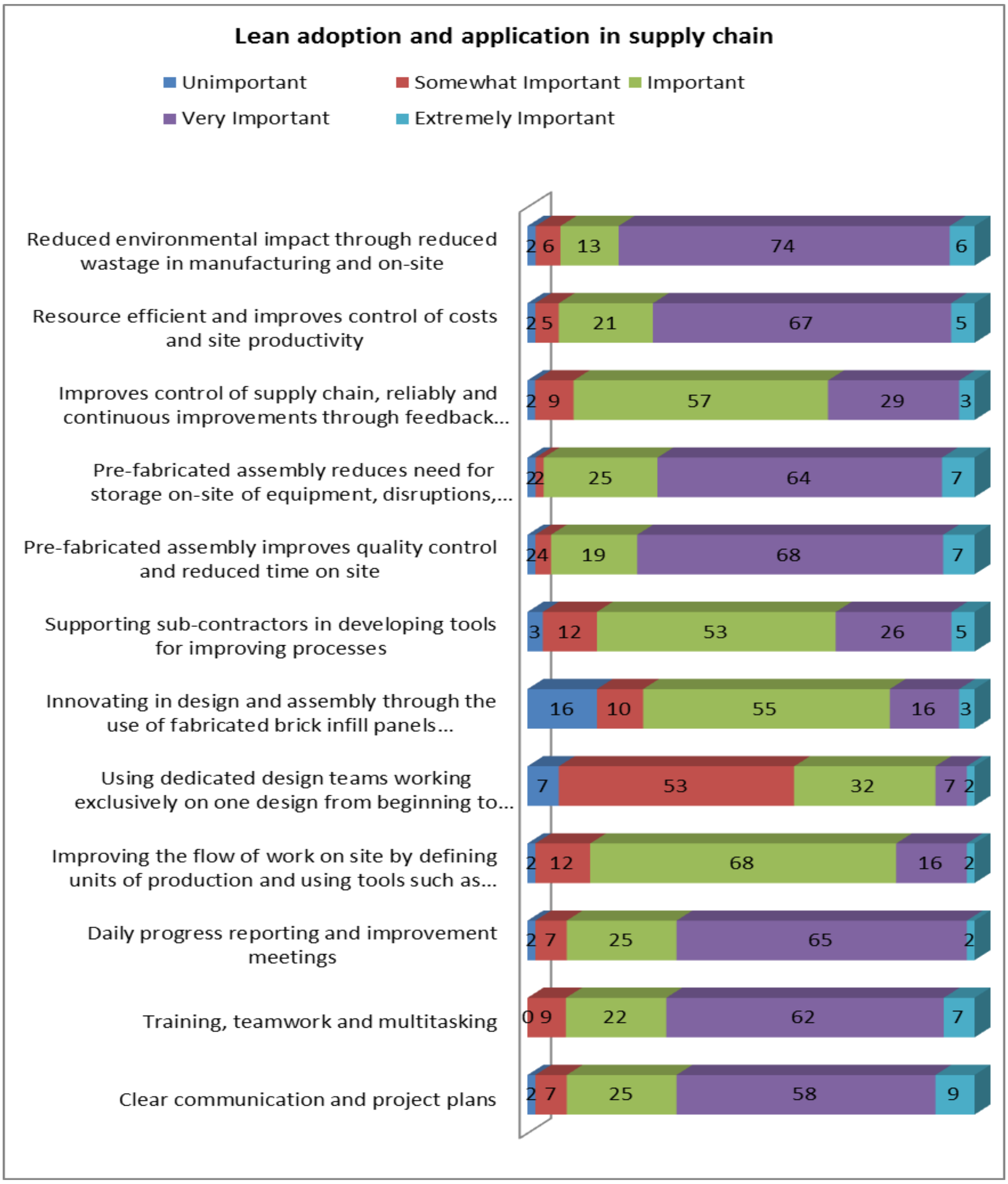


Figure 5.16 Lean adoption and application in supply chain

5.10.16. Lean Adoption in Product Production Process

About 44% respondents consider 'in depth understanding of production processes and resources involved in them', 'responsibility and authority placed with the workforce' (40% respondents) and 'benchmarking to establish 'best in class' production methods and outputs' (43% respondents) as somewhat important.

As for 'establishment of a stable project programme, with clear identification of critical path' (48% respondents) and 'real-time feedback on the performance (41% respondents) remain extremely important, Figure 5.17.

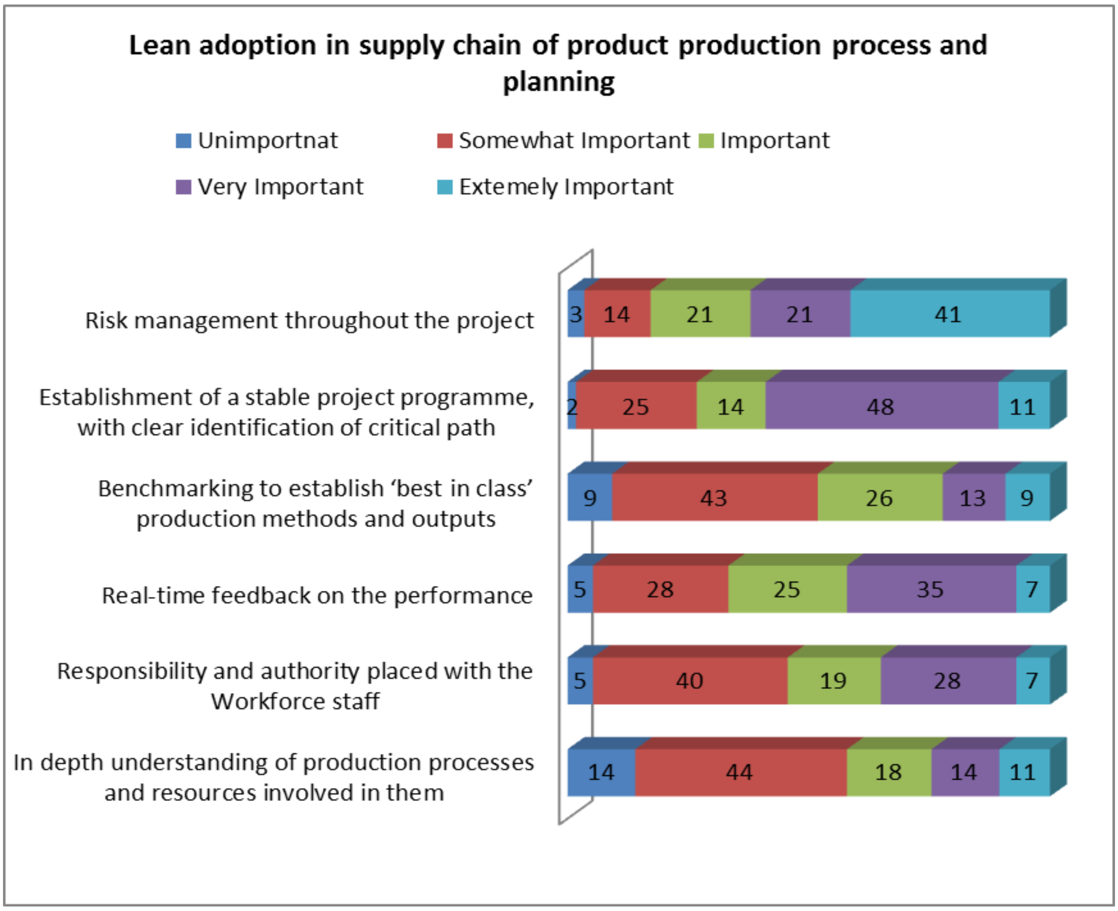


Figure 5.17 Lean adoption in supply chain of product production process and planning

5.10.17. Data Modification

In order to further modify the data, a session for industry practitioners was organised. This session had 12 participants, including project managers with many years' experience in managing the construction projects in the UK. The main aim of this session was to further examine the barriers and drivers; and this session's outcome was to be used for the case study. After examining the factors the industry participants had recommended that the factors be divided in three groups - company, industry and regulatory. These practitioners had further recommended that these groups be further divided into further three levels of developments. These variables and respective levels of developments are presented in Table 5.4.

	Attitude of ignorance with almost no reference to Supply chain or Industry Sustainability	**Involuntary or spontaneous response towards supply chain innovation and industry sustainability concerns for some elements of specific product/project requirements**	**Consistent and proactive response to supply chain innovation and industry sustainability driven by internal and external business environment**
Company			
Improve organisational performance	There was lack of understanding how organisational performance and industry sustainability connect and therefore no commitment	When bidding there was interest in sustainability issues and driven by procurement specs of the customers	There was clear understanding of short term and long term sustainability issues facing industry; therefore support for innovation in supply chain to be a profit enhancing initiative
Competitive advantage	Sustainability not linked to competitive advantage and there was no attempt to include innovative practices in the supply chain	There was recognition that considerations for industry sustainability through supply chain innovation can lead to competitive advantage	Use of supply chain innovation practices with the suppliers and customers is documented strategy for the organisation and clearly linked to organisations competitive advantage
Quality improvement	No link between industry sustainability and quality improvements	The external competitive drivers and quality initiatives shaped the organisational reaction and it was on project by project basis	The supply chain suppliers and customers required quality standards and there was commitment to continuous quality requirements
Enhanced organisational image	Sustainability doesn't lead to extra business and there is no strategy to enhance brand image through sustainability issues	The competitive pressure forces to consider supply chain innovation or industry sustainability issues and its temporary	The suppliers and customers of the organisation are also aware of the importance of the industry sustainability issues and continuously projecting brand association with Industry sustainability

Environmental partnerships with key suppliers leading to innovative practices	The view was 'it's difficult to partner because they are all competing and ultimately take our business'	The competitions initiatives forced the organisation to engage with some suppliers and consider partnerships - mainly on project by project initiative	The organisation considered the environmental partnerships as paramount and therefore proactively maintained both with the suppliers and customers in the supply chain
Organisations supply chain mission	There was no clear communication or engagement between suppliers or customers about the supply chain mission	Developing supply chain mission was considered to be a resource consuming initiatives with no clear paybacks identified - supply chain mission was communicated on case by cases when managing projects.	Both the suppliers and customers with clear supply chain mission are preferred choices and there is strong articulation of organisations supply chain mission
Drive from the senior management	There was no clear direction from the senior management to consider supply chain as key factor for industry sustainability	The supply chain and industry sustainability issues are considered in response to specific customer project needs and not considered to be a value adding commitment	The suppliers and customers commitment to supply chain and industry sustainability considerations are echoed by the organisational sentiments and led by senior management
Cost reduction or profit motivated	The supply chain and industry sustainability are not considered to be profit impacting initiatives	Only when customers demand the lifecycle costing are the supply chain and industry sustainability given serious considerations - in this case product features and benefits are accorded extra attention	The suppliers and customers in the overall value chain base their costing as lifecycle costing paying optimum attention to supply chain and industry sustainability issues
Corporate social responsibility	There was no talk of supply chain impacting the industry sustainability and therefore no reference to social issues impacting industry	The procurement practices of some of the suppliers, competitors and customers forces the organisation to look at the requirements from time to time.	The customers and the suppliers are also expected to be committed to corporate social responsibility and motivated without any external industry motivators or drivers

Middle management commitment	While the organisation promotes the importance of supply chain and its contribution to industry sustainability the middle management remains indifferent	The middle management commits resources as and when demanded by suppliers or in response to a particular supplier demand	There is proactive commitment from the middle management to continue to evolve supply chain practices and develop understanding of industry sustainability needs
Awareness of buyers supply chain practices	For some manufacturers there is poor awareness of customers supply chain practices	Manufacturers maintain sufficient understanding of customers supply chain practices and strictly on need to know basis	For some manufacturers maintain proactive understanding of customers supply chain and always seeking ways to improve efficiencies
Awareness of suppliers supply chain practices	Some manufacturers are indifferent to the suppliers supply chain practices	Manufacturers develop case by case understanding of suppliers supply chain to ensure the specific requirements are met.	The organisation maintains complete understanding of the supply chain and its strategic importance to organization is maintained
Organisational supply chain standards or audits initiatives	There is poor evidence of documented processes for supply chain standards as well as audit initiatives	Organisation maintains files on standards and audit requirements and refers to it as and when required by either customers or suppliers	The supply chain standards and the audit requirements are revised regularly and the departmental commitment is maintained
Industry			
Customer pressure	The customers are not able to impose any supply chain or industry sustainability requirements on the manufacturing companies	Case by case the customer specific needs around the supply chain and industry sustainability issues are addressed	The suppliers and the customers are aware of competitive advantage derived from supply chain innovation and therefore impacting industry sustainability
Global concern of Industry supply	The global concerns for the industry supply are not the drivers was considered to be impacting other organisations	The other industry players reaction to concern for global supply issues forces the organisation to adopt some temporary measures	The suppliers and the customers are aware of the global concerns and therefore directly impacts the organisational supply chain and sustainability issues

Rising cost of utilities of energy	The high cost of energy does not have much impact on the organisations operations and increasing cost is passed to customers	The fluctuating costs of energy and supplier as well as customer led reactions are forcing the organisation to respond to specific cost challenges	The supply chain activities are optimised irrespective of customer or supplier demands
Higher cost of disposal of waste material/products	The cost of disposal of waste material/products are not considered to be sufficient motivators to consider innovation in supply chain	Where the customer requires input from the manufacturer to provide specific input on the end of life disposal of products/materials the manufacturers provide information	The manufacturers and the suppliers work in partnership to ensure the cost of disposals is minimised and this is not motivated by any specific sustainability needs
Increasing scarcity of natural resources	The organisations strategic planning does not consider the scarcity of natural resources poses any immediate issues/concerns	Where the scarcity issues impacts the products or manufacturing process, the measures are adopted to ensure there is sufficient understanding amongst key functions in the organisation	The organisation proactively maintains understanding of global supply chain issues and monitor the scarcity in the natural resources that could have direct impact for the organisation
Information / Training about supply chain practices	There are no formal training requirements for supply chain practices in the organisation	The management maintains appropriate training records and participates in operations which requires customers and suppliers engagement in the supply chain	The organisation maintains proactive knowledge of all relevant training needs affecting the industry supply chain as well as customers-suppliers supply chain initiatives
Adopting complex innovative supply chain practices	The organisation adopts complex supply chain practices when the business orders or profits are impacted	The organisation commits resources when required by the customers and the suppliers	The organisation is continuously seeking to improve its products or solutions and therefore not reluctant to adopt complex innovative supply chain practices
Levels of returns on investments into supply chain innovation	Believe that the supply chain innovations cost more and provide little benefits in terms of extra returns	If the customers or suppliers invest in the innovative supply chain practices the organisation also invest in the supply chain innovation	There is continuous monitoring of the industry including supply chain innovation and the additional cost Vs additional revenues modelling is ongoing

Responsibility to adopt supply chain innovative practices	There is no willingness to adopt supply chain innovative practices unless forced to by wider industry applications	The organisation maintains good knowledge of the suppliers and customers needs and when forced by suppliers and customers takes responsibility of investment	The organisation takes proactive full responsibility in adopting innovative supply chain practices and ensure the new investment is integrated into existing operations efficiently
Supplier commitments / or willing to share information	There is no proactive seeking of information from suppliers to improve practices/operations	The organisation maintains strong links with the key suppliers and learn about new practices/operations	The organisation has joint thinking/partnership approach not only with suppliers but customers and the suppliers are incentivised to share information
Industry specific barriers	There is sufficient understanding of the key barriers faced	There is good understanding of how industry barriers affect the organisation	The organisation monitors the barriers proactively and develops good understanding of how these barriers affect its supply chain suppliers as well as customers
Price pressure driven by increasing competition	The competition for manufacturers is intense and this prevents any proactive expenditure	Manufacturers with wider products offerings or regular/established customer base are able to respond better to price pressure motivated by competition	There is proactive monitoring of business environment and cost, are proactively managed and new revenues streams are continuously identified
Higher cost of supply chain innovation initiative	Some consider innovative supply chain initiatives as additional expenditure and see no benefits	Based on supply chain evaluation the customers and suppliers are engaged and where necessary cost is not a main consideration for innovative initiatives in the supply chain	By monitoring the revenues generated Vs resources expended the costs considerations when considering innovative supply chain are not overwhelming factors in decision making
Regulatory			
Regulatory pressure	There are no specific regulations affecting organisations supply chain initiatives or its contribution to industry sustainability issues	The customers and suppliers reaction to regulatory requirement forces the organisation to adopt specific measures and remain project to project	The organisation remains proactive and ensures all suppliers and customers are compliant in its compliance to all supply chain and industry sustainability issues

Pressure of lobby group	The organisation practices are not impacted by the industry lobby groups	The impact of lobby group is considered since the customers or the suppliers practices are also likely to be affected	There is proactive approach to understand the different lobby groups and the drivers for these groups
Incentives from customers and government	For supply chain innovation or industry sustainability, in main, there was no incentive from either customers or government and even if there was it was not known	There was some understanding of incentives from government and sources of this knowledge was either customers or suppliers	As a result of the proactive approach to innovate supply chain and industry sustainability needs there was active research to identify incentives and the view was that the initiatives were not dependent on the incentives
Target country supply chain regulations	There was no awareness of specific regulations when exporting or selling products in to different regions of the country	Where supplying as part of the overall solution some countries industry requirements were understood	Some of the European countries had specific needs around the supply chain and industry sustainability and therefore it considered as proactive measure to ensure all the knowledge was acquired from relevant sources
Regional supply chain regulations for the industry	There is poor understanding of regional supply chain regulations impacting industry	There is sufficient understanding maintained and depending on the location of suppliers and customers	There is proactive recording of local, regional and national regulatory issues and how they impact on the organisational practices
Corrupt /bureaucratic environment	There is an understanding of the corrupt practices and bureaucratic practices that exist	The organisation maintains understanding corrupt and bureaucratic environment that exists in the industry while engaging with the suppliers and customers	The organisation proactively review and monitors its value chain including suppliers and customers for corrupt /bureaucratic practices

Table 5.4 Data modification for drivers and barriers of innovative supply chain

5.11. Framework for Further Data Analysis

Descriptive statistics were used for grouping all variable in the supply chain practices for the UK construction industry. For the variables 'Mean' and 'Standard Deviations' were extracted.

5.11.1. Main Drivers behind Innovative Supply

The factors which impact the organisational supply chain costs have mean average of 3.6. These are increasing cost of energy; higher cost of disposal of waste material/products, corporate social responsibility, increasing scarcity of natural resources and cost reduction or profit motivation.

Main drivers behind innovative supply chain practice	Mean	Std dev	Average mean
Cost impacting factors			
Rising cost of utilities of energy	3.49	.887	3.593
Higher cost of disposal of waste material/products	3.75	.869	
Corporate social responsibility	3.75	.888	
Increasing scarcity of natural resources	3.54	.886	
Cost reduction or profit motivated	3.43	.718	
Industry environment factors			
Target country supply chain regulations	2.90	.831	2.757
Pressure of lobby group	2.08	.918	
Global concern of Industry supply	2.54	1.433	
Environmental partnerships with key suppliers leading to innovative practices	2.93	.873	
Organisations supply chain mission	3.07	1.365	
Enhanced organisational image	3.02	.671	
Customer and Senior Management Drive			
Customer pressure	3.26	.751	3.164
Improve organisational performance	3.00	.913	
Drive from the senior management	3.23	.716	
Competitive factors			
Incentives from customers and government	2.61	.862	2.779
Competitive advantage	2.95	1.087	
Quality and Regulatory Factors			
Quality improvement	3.39	.971	3.262
Regulatory pressure	3.13	.939	

Table 5.5 Main drivers behind innovative supply chain practice

Furthermore, the industry environment factors have an average mean of nearly 3.0 (2.76). This factor includes the supply chain regulations; pressure of lobby groups; global concern of industry supply; environmental partnerships with key suppliers leading to innovative practices; organisations supply chain mission; and enhanced organisational image.

The customer and senior management drive, with average mean of 3.16, include customer pressure; improve organisational performance; and drive from the senior management.

The competitive factor includes, with mean average of 2.78, incentives from customers and government; and competitive advantage, Table 5.5.

The quality and regulatory factors, with mean average of 3.3, include quality improvement and regulatory pressure.

5.11.2. Main Barriers in Adopting Innovative Supply Chain Practices

The factor representing poor supply chain practices, regulations and supply chain standards have a mean average of 2.5. This factor includes poor regional supply chain regulations for the industry; poor awareness of suppliers supply chain practices; poor organisational supply chain standards or audits initiatives; and poor awareness of buyers supply chain practices.

The Industry barriers or suppliers reluctant to share information factor has average mean of 2.45 and include poor supplier commitments / or Unwilling to share information; and Industry specific barriers, table 5.6.

The Competitive pressure and avoidance of responsibility for innovative supply chain practices factor has mean average of 2.8 and include not organisations responsibility to adopt supply chain innovative practices; price pressure driven by increasing competition; lack of management commitment; and low returns of investments into supply chain innovation.

The lack of training and perceived complexity of innovative practices has mean average of 2.66 and includes innovative practices too complex to adopt; and lack of information / Lack of training about supply chain practices.

Main barriers in adopting innovative supply chain practices	Mean	Std dev	Avg. mean
Poor supply chain practices, regulations and standards			
Poor regional supply chain regulations for the industry	2.49	.788	2.488
Poor awareness of suppliers supply chain practices	2.46	.867	
Poor organisational supply chain standards or audits initiatives	2.38	.734	
Poor awareness of buyers supply chain practices	2.62	.897	
Industry barriers or suppliers reluctant to share information			
Poor supplier commitments / or Unwilling to share information	2.41	.783	2.451
Industry specific barriers	2.49	.849	
Competitive pressure and avoidance of responsibility for innovative supply chain practices			
Not organisations responsibility to adopt supply chain innovative practices	2.31	.886	2.811
Price pressure driven by increasing competition	2.66	.929	
Lack of management commitment	2.85	.727	
Low returns of investments into supply chain innovation	3.43	.921	
Lack of training and perceived complexity of innovative practices			
Innovative practices too complex to adopt	3.00	.949	2.656
Lack of information / Lack of training about supply chain practices	2.31	1.285	
cost of innovative supply chain supply chain and bureaucracy			
Higher cost of supply chain innovation initiatives	2.64	.967	2.164
Corrupt /bureaucratic environment	1.69	.743	

Table 5.6 Main barriers in adopting innovative supply chain practices

The cost of innovative supply chain supply chain and bureaucracy factor has mean average of 2.164 and includes higher cost of supply chain innovation initiatives; and corrupt /bureaucratic environment.

5.11.3. Impact of Economic Environment on Product Innovation

The 'impact of technology and uncertainty on product innovation' has a mean average of 2.86 and includes 'technological environment impacts product innovation'; 'country environment affects the type of product innovation in the company'; and 'continue product innovation in uncertain end changing environment' (Table 5.7).

Impact of Economic Environment on Product Innovation Process	Mean	Std dev	Avg. Mean
Impact of Technology and uncertainty on product innovation			
Technological environment impacts product innovation	3.20	.853	2.863
Country environment affects the type of product innovation in the company	2.56	1.191	
Continue product innovation in uncertain end changing environment	2.84	.840	
External environment impact on product innovation			
Product innovation dynamism driven by external environment	2.70	.989	2.803
Diversity in external environment impacts product innovation	2.90	.926	

Table 5.7 Impact of economic environment on product innovation process

The 'external environment impact on product innovation' has a mean average of 2.8 and includes 'product innovation dynamism driven by external environment'; and 'diversity in external environment impacts product innovation'.

5.11.4. Impact of Organisational Processes

The senior management initiatives have a mean average of 3.18. These includes methods of communications for effective information sharing with management; adoption of communication between team members and problem solving procedures; recognition of importance of team composition, format and structure for Product Innovation; leadership style matters in product innovation; CEO creates systems to recognise early breakthroughs and recognition of opportunity; and CEO creates creativity friendly climate (Table 5.8).

The ‘product innovation initiatives’ have a mean average of 2.93. These include ‘impact of organisational size and impact on product innovation’; ‘product innovation impacted by competition and aggression’; ‘impact of marketing orientation on the product innovation’; ‘CEO creates product innovation teams’; and ‘CEO creates models to follow and style product innovation’.

Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	Mean	Std dev	Avg. Mean
Senior management initiatives			
Methods of communications for effective information sharing with management	3.16	.688	3.18
Adoption of communication between team members and problem solving procedures	3.08	.714	
Recognition of importance of team composition, format and structure for Product Innovation	3.21	.733	
Leadership style matters in product innovation	3.39	.822	
CEO creates systems to recognise early breakthroughs and recognition of opportunity	3.08	.557	
CEO creates creativity friendly climate	3.13	.670	
Product Innovation initiatives			
Impact of organisational size and impact on product innovation	3.00	.753	2.93
Product innovation impacted by competition and aggression	2.93	.750	
Impact of marketing orientation on the product innovation	2.98	.764	
CEO creates product innovation teams	2.82	.847	
CEO creates models to follow and style product innovation	2.93	.629	
Senior and middle management coordination			
Organisational power structure impacts on product innovation	3.00	.753	2.96
Impact of board or senior management diversity on product innovation	2.36	.797	
CEO and top management work together to response to environment and identify new innovative products	3.51	.868	
Chief Executive commitment			
CEO characteristics, and personal attributes matter	3.54	.743	3.31
Link between overall strategy, the process of strategy development and product innovation matters	3.10	.569	
CEO creates informal structural mechanisms	3.30	.738	

Table 5.8 Impact of organisational processes

The ‘senior and middle management coordination’ have a mean average of 2.96 and includes ‘organisational power structure impacts on product innovation’; ‘impact of board or senior management diversity on product innovation’; and ‘CEO and top management work together to response to environment and identify new innovative products’.

The Chief Executive commitment has a mean average of 3.31 and includes ‘CEO characteristics, and personal attributes matter’; ‘link between overall strategy, the process of strategy development and product innovation matters’; and ‘CEO creates informal structural mechanisms’.

5.11.5. Key elements of Innovative Supply Chain Practices

The ‘engagement with innovative suppliers’ has an average mean value of 2.6. This factor includes ‘bringing together suppliers in the industry to share their expertise and problems’; ‘organising workshops/ seminars for suppliers on innovative’; ‘recognitions and awards for innovative supply chain practitioners’; ‘sharing technical expertise with suppliers’; and ‘choice of suppliers by innovative supply’ (Table 5.9).

The Partnership with suppliers has an average mean value of 3.3. This factor includes; encouraging suppliers to have ISO14001 certification; auditing suppliers to evaluate their environmental performance; evaluating suppliers supply chain practices; and use lifecycle analysis to measure the innovation within the products and packaging.

The ‘engagement with suppliers during design’ has a mean average value of 3.04. This factor includes; participating in the design of products for recycling or reuse; participating in the design of products for packaging; and ensuring supplier to commit to reduce waste by adopting innovation.

The Proactive supply chain innovation has mean average value of 2.94 and includes purchase products that have innovative attributes; work with industry suppliers to improve their supply chain practices; and working with suppliers to innovate supply chain through product design and material usage.

Key elements of innovative supply chain practices	Mean	Std dev	Avg. Mean
Engagement with innovative suppliers			
Bringing together suppliers in the industry to share their expertise and problems	2.15	1.152	2.559
Organising workshops/ seminars for suppliers on innovative	2.38	1.195	
Recognitions and awards for innovative supply chain practitioners	2.31	.886	
Sharing technical expertise with suppliers	3.10	.700	
Choice of suppliers by innovative supply	2.85	.963	
Partnership with suppliers			
Encouraging suppliers to have ISO14001 certification	3.44	1.272	3.283
Auditing suppliers to evaluate their environmental performance	3.43	1.056	
Evaluating suppliers supply chain practices	3.02	.922	
Use lifecycle analysis to measure the innovation within the products and packaging	3.25	1.027	
Engagement with suppliers during design			
Participating in the design of products for recycling or reuse	3.02	.904	3.038
Participating in the design of products for packaging	3.07	.793	
Ensuring supplier to commit to reduce waste by adopting innovation	3.03	1.221	
Proactive supply chain innovation			
Purchase products that have innovative attributes	2.93	.929	2.940
Work with industry suppliers to improve their supply chain practices	2.97	1.110	
Working with suppliers to innovate supply chain through product design and material usage	2.92	.862	

Table 5.9 Key elements of innovative supply chain practices

5.11.6. Innovative Product Design Practices

The ‘innovative product design practice’ factor has a mean average value of 2.84. This includes designing innovative products to reduce emission; innovative design of products for reuse, recycle, recovery of material and sub-assembly products; designing innovative products to reduce consumption of energy; adopting new material for products; using lifecycle analysis for products; and innovative design for reduced waste generation/material consumption (Table 5.10).

Innovative Product Design Practices	Mean	Std dev	Avg. Mean
Innovative product design practice			
Designing innovative products to reduce emission	2.90	1.028	2.839
Innovative design of products for reuse, recycle, recovery of material and sub-assembly products	2.79	.859	
Designing innovative products to reduce consumption of energy	2.93	1.014	
Adopting new material for products	2.85	.963	
Using lifecycle analysis for products	2.85	.946	
Innovative design for reduced waste generation / material consumption	2.70	.937	

Table 5.10 Innovative product design practices

5.11.7. Lean Application and Adoption in design and product / materials development process

The Lean design processes factor has mean average value of 2.87. This factor includes value management to achieve more understanding and focus on client value; concurrent working between manufacturer and supplier during design development; carry-over to new models of a high proportion of systems and components from previous model; use of visualization techniques such as virtual reality and 3D CAD to fully define the product requirements from the customer’s perspective; and front-loading of resources towards design to prevent problems during manufacturing, Table 5.11.

The Lean design understanding factor has mean average value of 2.99. This includes design for standardization and pre-assembly processes and product components to achieve higher quality, cost and time savings; use of integrated design and build arrangements – such as partnering – to encourage close cooperation between designers, constructors and specialist suppliers; and design is informed by extensive data on performance of products, systems and components.

Lean Application and Adoption in design and product / materials development process	Mean	Std dev	Avg. Mean
Lean design processes			
Value management to achieve more understanding and focus on client value	2.98	.671	2.872
Concurrent working between manufacturer and supplier during design development	2.92	.781	
Carry-over to new models of a high proportion of systems and components from previous model	2.70	.919	
Use of visualization techniques such as virtual reality and 3D CAD to fully define the product requirements from the customer's perspective	2.84	.898	
Front-loading of resources towards design to prevent problems during manufacturing	2.92	.900	
Lean design understanding			
Design for standardization and pre-assembly processes and product components to achieve higher quality, cost and time savings	3.18	.992	2.989
Use of integrated design and build arrangements – such as partnering – to encourage close cooperation between designers, constructors and specialist suppliers	3.44	1.385	
Design is informed by extensive data on performance of products, systems and components	2.34	.929	

Table 5.11 Lean application and adoption in the design and product/materials development process

5.11.8. Innovative Products Production/Operations Practices

The Innovative operational efficiencies factor has a mean average value of 2.83. This includes production and operational planning and control focused on reducing waste optimising innovative materials exploitation; interdepartmental cooperation for innovative improvements in the supply chain; recycling organisational supply chain waste; and use of innovative cleaner technology to save energy, waste etc (Table 5.12). The reduction of supply chain waste and carbon emission has an average mean value of 2.1. This factor includes modifying production/operation processes to reduce supply chain liquid waste; modify production/operation processes to reduce supply chain solid waste; and modify production/operation processes to reduce carbon emission.

Innovative Products Production/Operations Practices	Mean	Std dev	Avg. Mean
Innovative operational efficiencies			
Production and operational planning and control focused on reducing waste optimising innovative materials exploitation	2.77	1.216	2.828
Interdepartmental Cooperation for innovative improvements in the supply chain	3.00	1.095	
Recycling organisational supply chain waste	2.59	1.006	
Use innovative cleaner technology to save energy, waste etc.	2.95	.845	
Reducing supply chain waste and carbon emission			
Modify production/operation processes to reduce supply chain liquid waste	2.08	.737	2.093
Modify production/operation processes to reduce supply chain solid waste	1.85	1.014	
Modify production/operation processes to reduce carbon emission	2.34	1.365	

Table 5.12 Innovative products production/operations practices

5.11.9. Customer Engagement Practices

The Customer Engagement factor has an average mean value of 3.7. This factor includes; ‘we believe this business exists primarily to serve customers’; ‘we are more customers focused than our competitors’; and ‘we poll end user's at least once a year to assess the quality of our products and services’ (Table 5.13).

The Customer needs shared within the company factor has a mean average value of 3.86 and includes; ‘we freely communicate information about our successful and unsuccessful customer experiences across all business functions’; ‘our strategy for competitive advantage is based on our understanding of customers’ needs’.

The Customer Feedback factor has a mean average value of 3.09 and includes; ‘we measure customer satisfaction systematically and frequently’; ‘we have routine or regular measures of customer service’; and ‘data on customer satisfaction are disseminated at all levels in this business unit on a regular basis’.

Customer Engagement Practices	Mean	Std dev	Avg. Mean
Customer Engagement			
We believe this business exists primarily to serve customers	3.84	.952	3.69
We are more customers focused than our competitors.	3.56	.992	
We poll end user's at least once a year to assess the quality of our products and services	3.67	.870	
Customer needs shared within the company			
We freely communicate information about our successful and unsuccessful customer experiences across all business functions	3.62	.934	3.86
Our strategy for competitive advantage is based on our understanding of customers' needs.	4.10	1.165	
Customer Feedback			
We measure customer satisfaction systematically and frequently	2.84	1.128	3.09
We have routine or regular measures of customer service	3.31	.765	
Data on customer satisfaction are disseminated at all levels in this business unit on a regular basis	3.11	.777	
Customer focus			
Our business objectives are driven primarily by customer satisfaction	3.16	.820	3.16
We constantly monitor our level of commitment and orientation to serving customer needs	3.16	.840	

Table 5.13 Customer engagement practices

The Customer focus factor has a mean average value of 3.16 and includes; 'our business objectives are driven primarily by customer satisfaction'; and 'we constantly monitor our level of commitment and orientation to serving customer needs'.

5.11.10. Innovative Supply Chain Management

The supply chain management in organisation factor has mean average value of 3.05; This includes; inter-departmental cooperation for supply chain improvements; ISO14001 certification; supply chain policy; supply chain compliance; and auditing programmes (Table 5.15).

Innovative supply chain management practices	Mean	Std dev	Avg. Mean
Supply chain management in Organisation			
Interdepartmental cooperation for supply chain improvements	3.38	.969	3.05
ISO14001 certification	3.07	1.590	
Supply chain policy	2.84	.916	
Supply chain compliance and auditing programmes	2.90	.870	
Supply chain commitment from all departments			
Disclosure or sharing of Supply chain practices records	2.77	.990	2.76
Supply chain training and awareness programme for employees	2.54	.993	
Commitment from the top management for innovative practices in the supply chain	2.92	.936	
Rewards and incentives for the employees demonstrating innovative supply chain ideas /initiatives	2.82	1.103	

Table 5.14 Innovative supply chain management

The supply chain commitment from all departments factor has a mean average value of 2.76. This factor includes disclosure or sharing of Supply chain practices records; supply chain training and awareness programme for employees; commitment from the top management for innovative practices in the supply chain; rewards and incentives for the employees demonstrating innovative supply chain ideas /initiatives.

5.11.11. Innovative Marketing Practices

The Innovative Marketing factor has a mean average value of 2.66. This factor includes using innovative packaging; recollecting the Packaging; purchase recycled packaging; recovery of company's end of life products; eco-and labelling products (Table 5.15).

Innovative Marketing Practices	Sum	Std dev	Avg. Mean
Innovative Marketing			
Using innovative packaging	2.46	1.163	2.66
Recollecting the Packaging	2.33	.978	
Purchase recycled packaging	2.49	.960	
Recovery of company's end of life products	2.82	.847	
Eco-labelling products	3.18	1.118	

Table 5.15 Sum and standard deviation Innovative marketing practices

5.11.12. Performance Measures

Performance measures	Mean	Std dev	Avg. Mean
Improved Business efficiencies			
Improvement in environmental quality of products / services through innovative supply chain practices	3.13	.806	3.01
Improve recycling of products and materials through innovative supply chain practices	3.10	.870	
Increase in the market share as a result of innovative supply chain practices	2.54	1.010	
Productivity improvements through supply chain innovation	3.28	.839	
Improved compliance			
Decrease in consumption of hazardous material through innovative practices	3.10	.831	3.01
Reduction in frequency of environmental incidents/accidents through innovative supply chain practices	3.00	.856	
Supply chain compliance improvement	2.92	.862	
Economic gains			
Innovative supply chain practices leading to increased energy efficiency	3.08	.988	3.03
Investment recovery through sale of additional inventories and materials through innovation in supply chain	2.77	.902	
Increased profit margins as a result of innovative supply chain practices	3.23	.956	
Cost and waste reductions			
Cost reduction as a result of innovative supply chain practices	3.48	.887	3.41
Reduction in waste through innovative supply chain practices	3.34	.892	
Improve environmental image			
Reduce environmental discharge through innovative supply chain practices	3.15	.928	3.09
Improve brand image through innovative supply chain practices	3.03	.730	

Table 5.16 Mean and standard deviation of performance measures

The ‘Improved Business efficiencies’ factor has a mean average value of 3.01. This factor includes improvement in environmental quality of products/services through innovative supply chain practices; improving recycling of products and materials through innovative supply chain practices; increase in the market share as a result of innovative supply chain practices; and productivity improvements through supply chain innovation (Table 5.16).

The Improved compliance factor includes mean average value of 3.01. This factor includes decrease in consumption of hazardous material through innovative practices; reduction in frequency of environmental incidents/accidents through innovative supply chain practices; and supply chain compliance improvement.

The economic gains factor has a mean average value of 3.03. This factor includes innovative supply chain practices leading to increased energy efficiency; investment recovery through sale of additional inventories and materials through innovation in supply chain; and increased profit margins as a result of innovative supply chain practices.

The cost and waste reductions factor has a mean average value of 3.41 and includes; cost reduction as a result of innovative supply chain practices; and reduction in waste through innovative supply chain practices.

Improve environmental factor has a mean average value of 3.09 and includes; reducing environmental discharge through innovative supply chain practices; and improving brand image through innovative supply chain practices.

5.11.13. Using nearby Supply Chain Sources

The Use of reverse logistics factor has a mean average value of 2.80. This factor includes use of reverse logistics; using innovative supply chain friendly transportation; and innovative supply chain innovative consolidation (Table 5.17).

The logistics quality factor has a mean average value of 3.01. This factor use of standardised reusable containers/packaging in innovative supply chain logistics practices; the use of benchmarking of suppliers’ performance against each other on a range of generic criteria; and Just-in-time delivery of materials to the point of eliminating the need for on-site storage and double-handling.

Use of reverse logistics Practices	Mean	Std dev	Avg. Mean
Use of reverse logistics			
Use of reverse logistics	3.05	.825	2.80
Using innovative supply chain friendly transportation	2.95	.784	
Innovative supply chain innovative consolidation	2.41	.824	
Logistics quality			
Use of standardised reusable containers / packaging in innovative supply chain logistics practices	3.07	.704	3.01
The use of benchmarking of suppliers' performance against each other on a range of generic criteria	2.87	.806	
Just-in-time delivery of materials to the point of to eliminate the need for on-site storage and double-handling	3.08	.671	
Close relations with first tier suppliers			
The development of close relations with first tier suppliers	4.26	.982	3.87
Lack of reliance on formal contracts	3.48	.829	
Using nearby supply chain sources			
Using nearby supply chain sources	3.13	.763	3.13

Table 5.17 Mean and standard deviation of using nearby supply chain sources

The Close relation with first tier supplier's factor has a mean average value of 3.87 and this factor includes the development of close relations with first tier suppliers; and lack of reliance on formal contracts.

The Using nearby supply chain sources factor is also important with mean average value of 3.13.

5.11.14. Semi-Automated Equipment Adoption

The Semi-automated improves cost and production efficiencies factor has a mean average value of 3.04 and includes semi-automated equipment reduces construction costs; and semi-automated equipment improves productivity due to shorter delivery times (Table 5.18).

The Semi-automated safety quality improvements factor has a mean average value of 3.66 and includes, 'semi-automated equipment improves safety by allowing workers to stay out of danger zone'; and 'semi-automated equipment provides higher quality by reducing workmanship errors and higher accuracy'.

Semi-Automated Equipment Adoption	Mean	Std dev	Avg. Mean
Semi-automated improves cost and production efficiencies			
Semi-automated equipment reduces construction costs	2.97	1.154	3.04
Semi-automated equipment improves productivity due to shorter delivery times	3.11	1.034	
Semi-automated safety quality improvements			
Semi-automated equipment improves safety by allowing workers to stay out of danger zone	3.89	1.156	3.66
Semi-automated equipment provides higher quality by reducing workmanship errors and higher accuracy	3.43	.957	

Table 5.18 Mean and standard deviation of semi-automated equipment adoption

5.11.15. Lean Adoption and Application in Supply Chain

The Preference for Pre-fabricated products has a mean average value of 3.59. This includes; 'pre-fabricated assembly reduces need for storage on-site of equipment, disruptions, labour costs, noise and waste'; 'reduced environmental impact through reduced wastage in manufacturing and on-site'; 'pre-fabricated assembly improves quality control and reduced time on site'; and 'resource efficient and improves control of costs and site productivity (Table 5.19).

The process efficiencies factor has a mean average value of 3.40. This includes clear communication and project plans; training, teamwork and multitasking; and daily progress reporting and improvement meetings.

The 'Adoption of operational efficiency tools' has a mean average value of 3.12 and includes improving the flow of work on site by defining units of production and using tools such as visual control of processes; and improves control of supply chain, reliably and continuous improvements through feedback loops.

The 'End to end design thinking' factor has mean average value of 2.78. This includes innovating in design and assembly through the use of fabricated brick infill panels manufactured off site and pre-assembled roofs lifted in to place; supporting sub-contractors in developing tools for improving processes; and using dedicated design teams working exclusively on one design from beginning to end and developing a tool to significantly speed up design process

Lean Adoption and Application in Supply Chain	Mean	Std dev	Avg. Mean
Preference for Pre-fabricated products			
Pre-fabricated assembly reduces need for storage on-site of equipment, disruptions, labour costs, noise and waste	3.59	.844	3.59
Reduced environmental impact through reduced wastage in manufacturing and on-site	3.70	.882	
Pre-fabricated assembly improves quality control and reduced time on site	3.59	.804	
Resource efficient and improves control of costs and site productivity	3.48	.849	
Process efficiencies			
Clear communication and project plans	3.28	1.019	3.40
Training, teamwork and multitasking	3.34	.964	
Daily progress reporting and improvement meetings	3.57	.939	
Adoption of operational efficiency tools			
Improving the flow of work on site by defining units of production and using tools such as visual control of processes	3.08	.759	3.12
Improves control of supply chain, reliably and continuous improvements through feedback loops	3.16	.734	
End to end design thinking			
Innovating in design and assembly through the use of fabricated brick infill panels manufactured off site and pre-assembled roofs lifted in to place	2.74	.998	2.78
Supporting sub-contractors in developing tools for improving processes	3.10	.889	
Using dedicated design teams working exclusively on one design from beginning to end and developing a tools to significantly speed up design process	2.49	.994	

Table 5.19 Mean and standard deviation of lean adoption and application in supply chain

5.11.16. Lean Adoption in Supply Chain of Product Development

Lean Adoption in Supply Chain of Product Production Process	Mean	Std dev	Avg. Mean
Innovative production process			
In depth understanding of production processes and resources involved in them	2.75	1.178	3.044
Responsibility and authority placed with the Workforce staff	3.16	.986	
Benchmarking to establish 'best in class' production methods and outputs	3.21	1.035	
Project management Efficiencies			
Establishment of a stable project programme, with clear identification of critical path	2.75	.994	3.317
Real-time feedback on the performance	3.34	1.047	
Risk management throughout the project	3.85	1.152	

Table 5.20 Mean and standard deviation of lean adoption in supply chain of product production process

The Innovative production process has a mean average value of 3.044. This includes in depth understanding of production processes and resources involved in them; responsibility and authority placed with the Workforce staff; and benchmarking to establish 'best in class' production methods and outputs (Table 5.20).

The project management efficiencies factor has mean average value of 3.32. This factor includes; establishment of stable project programme, with clear identification of critical path; real-time feedback on the performance; and risk management throughout the project, Table 5.20.

5.12. Designing the Hypothesis

To examine the relationships between the Company, Industrial and Regulatory themes identified and the organisational practices 11 hypothesis were developed (see Figure 5.18). These themes and respective factors were identified after consultation with the representatives from the target manufacturing companies and construction company's representatives.

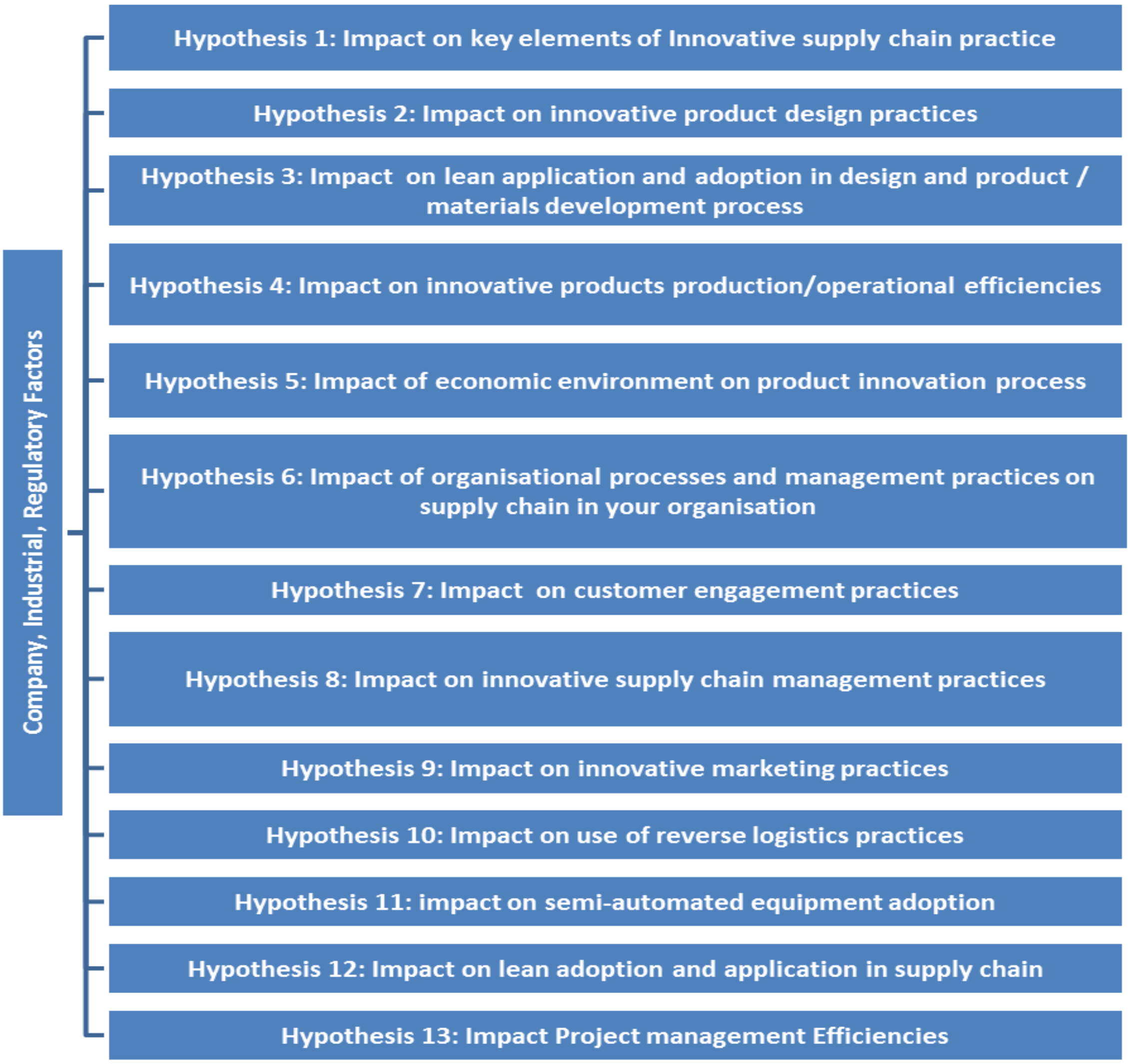


Figure 5.18 Main hypothesis

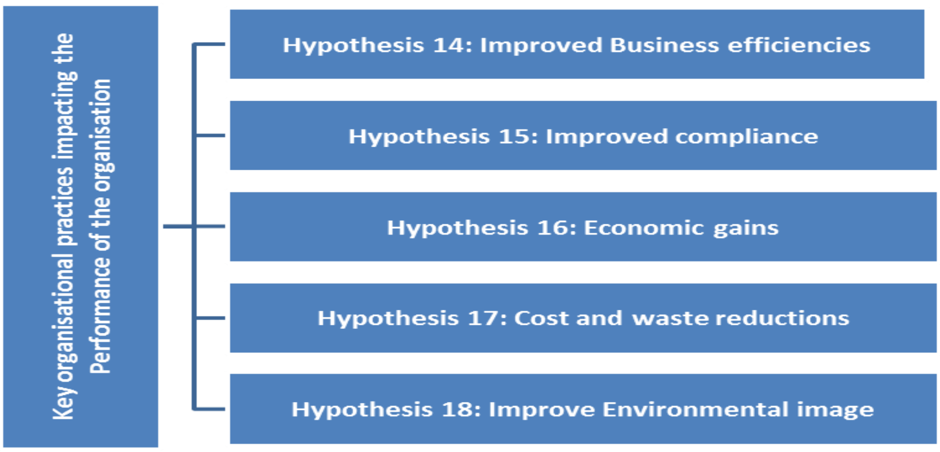


Figure 5.19 Sub hypothesis

The second set of five hypotheses considers the impact of different organisational practices on the performance of the organisations.

5.12.1. Innovative Supply Chain Practices

H1: the company, industrial and regulatory factors positively affect key elements of innovative supply chain practice

It was important to measure impact of company-industry-regulatory factors on the innovative supply chain practices of the organisations.

Correlations					
		Total 2.1 - Key elements of innovative supply chain practices	Company Factors	Industry Factors	Regulatory Factors
Pearson Correlation	Key elements of innovative supply chain practices	1.000			
	Company factors	.041	1.000		
	Industry factors	-.108	.523	1.000	
	Regulatory factors	-.100	.431	.135	1.000
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.21 Correlation between Company, Industrial and Regulatory factors and key elements of innovative supply chain practices

The SPSS output (Table 5.21) provides a matrix of correlation coefficients for the three variables - company, industrial and regulatory and its impact on the Key elements of Innovative supply chain practices. Underneath each correlation coefficient both the significance value of the correlation and the sample size (N) on which it is based are displayed. Each variable is perfectly correlated with itself and r = 1 along the diagonal of the table.

Key elements of innovative supply chain practices are negatively related to industrial (-.108) factors and the significance value is greater than .01. This tells us that the null hypothesis is true and there is no relationship between variables; and Key elements of Innovative supply chain practices are negatively related to the regulatory (-.100) factors. Furthermore, the significance level being greater than .01, there is no relationship between the variables.

In the main, this all means that the company factors (r = .041, significance = .753) has slight impact on the key elements of innovative supply chain practices. Conversely, the industrial and regulatory factors have no impact.

Therefore, it can be assumed that there is a complex relationship between the variables with poor correlation between the dependent and the independent variables.

Model Summary										
					Change Statistics					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**R Square Change**	**F Change**	**df1**	**df2**	**Sig. F Change**	**Durbin-Watson**
1	**.218[a]**	**.047**	**-.003**	**.604**	**.047**	**.944**	**3**	**57**	**.426**	**2.115**
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Total 2.1 - Key elements of Innovative supply chain practices										

Table 5.22 Multiple Regression Analysis – Model Summary

First, looked at model summary Table 5.22, the coefficient of correlation (R) is .218 while coefficient of determination (R square) is .047. R-square tells us the "goodness of fit" of the model and we can think of it as a percentage. Our R-square for this model is .047, which means that the company, industrial and organisational variables explain about 4.7% of the change in key elements of the innovative supply chain practices. That is the independent variables explain 4.7% of variation in the Key elements of innovative supply chain practices. The difference between the R square and adjusted R square means that the model would account for 5% [.047- (-.003)] or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .604; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values.

The value of the Durbin Watson statistics is 2.115 which is higher than 2.0 and indicates that the assumption of independent error has been met.

In the multiple regression, Table 5.23 ANOVA, the F-test (.944), confirms to us if the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is .426 > .05, so we cannot reject the null hypothesis that - the model has no predictive value.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.032	3	.344	**.944**	.426[b]
	Residual	20.777	57	.365		
	Total	21.808	60			
a. Dependent Variable: Total 2.1 - Key elements of Innovative supply chain practices						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.23 Multiple Regression Analysis - Anova

5.12.2. Innovative Product Design Practices

H2: the company, industrial and regulatory factors positively affect innovative product design practices

It was important to measure impact of company-industry-regulatory factors on the innovative product design practices as well, Table 5.24.

Innovative Product Design Practices is poorly related to regulatory (.019) factors and the significance value is .885 > .01; somewhat related to industrial (.322) factors and the significance value is .011 > .01; and somewhat related to company (.310) factors and the significance value is .015 > .01.

Correlations					
		Innovative Product Design Practices	Company Factors	Industry Factors	Regulatory Factors
Innovative Product Design Practices	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	.310*	1		
	Sig. (2-tailed)	.015			
	N	61	61		
Industry Factors	Pearson Correlation	.322*	.523**	1	
	Sig. (2-tailed)	.011	.000		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	.019	.431**	.135	1
	Sig. (2-tailed)	.885	.001	.300	
	N	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.24 Correlation between Company, Industrial and Regulatory factors and innovative product design practices

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.378[a]	.143	.098	.739	.143	3.161	3	57	.031	2.009
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Innovative Product Design Practices										

Table 5.25 Multiple Regression Analysis of innovative product design practices – Model Summary

Table 5.25 tells us that the null hypothesis is not true and there is minor relationship between variables. In the main, this means that the company factor has some impact on the product design practices.

In this model summary, the coefficient of correlation (R) is .378 while coefficient of determination (R square) is .143. This means that the company, industrial and organisational variables explain about 14.3% of the variance in ‘Innovative Product design practices#. That is, the independent variables explain 14.3% of variation in the innovative product design practices. The difference between the R square and adjusted R square means that the model would account 4.5% (.143 - .098) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .739; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.009 which is higher than 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.174	3	1.725	3.161	.031[b]
	Residual	31.102	57	.546		
	Total	36.276	60			
a. Dependent Variable: Innovative Product Design Practices						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.26 Multiple Regression Analysis of innovative product design practices

For this model, Table 5.26 ANOVA, the F-test (3.161), confirms to us that the model can predict innovative product practices using the Company, Industrial and Organisational factors. The significance is .031 < .05, so we can reject the null hypothesis that the model has no predictive value.

The first coefficient (Constant = .602) is intercept term, Table 5.27. That is, before accounting for the dependent variable(s) - when X is zero – this is the value of Y. In this case, the intercept is .602, so when X=0, Y will equal .602 (regression equations Y = b0 + b1x1).

In multiple regressions the model takes the form of an equation that contains coefficient B for each predictor. The First part of the table gives estimates for these B values and these values indicate the individual contribution of each predictor.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.602	.922		.653	.516
	Company Factors	.466	.293	.253	1.591	.117
	Industry Factors	.462	.325	.206	1.420	.161
	Regulatory Factors	-.205	.238	-.118	-.862	.392
a. Dependent Variable: Innovative Product Design Practices						

Table 5.27 Coefficients – Innovative Product Design Practices

If the B values is positive we can tell that there is a positive relationship between the predictor and the outcome whereas a negative coefficient represents a negative relationship between the predictor and the outcome where as a negative coefficient represents a negative relationship. The B values also indicate to what extent each predictor affects the outcome if the effects of all other predictors are held constant. Each of these B values have an associated standard error indicating the extent to what these values will vary across different samples and these standard errors are used to determine whether or not the B values differs significantly from zero. Therefore, if the t-test associated with a B value differs significant (if sig. column values are less than .05) that predictor is making a significant contribution to the model.

In the main, the smaller the value of significance (Sig.) and larger the value of t, the contribution of the predictor is greater.

The B values and their significance are important statistics to look at; however, the standardized versions of the B values are easier to interpret because they are not dependent on the units of measurement of the variables. The standardized β values are provided by SPSS and they tell us the number of standard deviations that the outcome will change as a result of one standard deviation change in the predictor. The standardised β (beta) values are all measured in standard deviation units and therefore are directly comparable. That is, they provide a better insight into the 'importance' of a predictor in the model. This normally tells us that the predictors have a slightly more impact on the model.

Innovative Product Design = .602 + .0.253* Company + .0.206* Industrial + (-.118*Regulatory)

5.12.3. Lean Application and Adoption in Design and Product/Materials development process

H3: the company, industrial and regulatory factors positively affect Lean Application and Adoption in design and product / materials development process

In Table 5.28, lean application and adoption in design and product / materials development process is poorly related to regulatory (.171) factors and the significance value is .188 > .01; somewhat related to industrial (.249) factors and the significance value is .053 > .01; and poorly related to company (.097) factors and the significance value is .458 > .01.

In Table 5.29, column labelled ‘R’ are the values of multiple correlation coefficient between the independent variables, ‘Regulatory Factors’, ‘Industry Factors’, ‘Company Factors’ and the dependent variable, ‘Lean design understanding’. For this model, this is the simple correlation between the predictors and the dependent variable (0.305).

The R Square value tells us that it is a measure of how much of the variability of the outcome is accounted for by the independent variables. For our model its value is .093, which means that Regulatory Factors, Industry Factors, Company Factors accounts for 9.3% of the variation in Lean design understanding.

The adjusted R Square gives us some of how well our model generalizes and ideally, we would like its value to be the same, or very close to, the value of R Square. In this model the difference for the final model is .212 (.093 - .045 = .048 or 4.8%) is noticeable. This means that if the model were derived from the population rather than the sample it would account for approximately 4.8% less variance in the outcome.

Correlations					
		Lean design understanding	Company Factors	Industry Factors	Regulatory Factors
Lean design understanding	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	.097	1		
	Sig. (2-tailed)	.458			
	N	61	61		
Industry Factors	Pearson Correlation	.249	.523**	1	
	Sig. (2-tailed)	.053	.000		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	.171	.431**	.135	1
	Sig. (2-tailed)	.188	.001	.300	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.28 Correlation between Company, Industrial and Regulatory factors and lean design understanding

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.305[a]	.093	.045	.637	.093	1.943	3	57	.133	1.497
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Lean design understanding										

Table 5.29 Model Summary on lean design understanding

The Durbin-Watson statistic informs about whether the assumption of independent errors is tenable. Below or the closer to 2 that value, the better; and for these data the value is 1.409. So, the assumption has been met.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.365	3	.788	1.943	.133[b]
	Residual	23.129	57	.406		
	Total	25.494	60			
a. Dependent Variable: Lean design understanding						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.30 Analysis of variance on lean design understanding

An analysis of Variance (ANOVA) that tests whether the model is significantly better at predicting the outcome than using the means as the most appropriate guess, Table 5.30.

Coefficients								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.268	.795		1.595	.116		
	Company Factors	-.217	.253	-.141	-.861	.393	.594	1.684
	Industry Factors	.558	.281	.296	1.989	.052	.716	1.397
	Regulatory Factors	.279	.205	.191	1.360	.179	.803	1.245
a. Dependent Variable: Lean design understanding								

Table 5.31 Coefficients – Lean Design Understanding

Specifically, the F-ratio represents the ratio of the improvement in prediction that results from fitting the model, relative to the inaccuracy that still exists in the model.

If the improvement due to fitting the regression model is much greater than the inaccuracy within the model then the value of F will be greater than 1 and SPSS calculates the exact probability of obtaining the value of F by chance. For the initial model the F-ratio is 1.943 but not highly significant since p = .133 > 0.001.

The logical interpretation of this is that we cannot reject the null hypothesis.

The first coefficient (Constant = 1.268) is intercept term. In this case, the intercept is .1.268, so when X=0, Y will equal 1.268 (regression equations Y = b0 + b1x1), Table 5.31.

The B values tell us about the relationship between Lean Design Understanding and each predictor. For the regulatory factor the value is positive (.191) we can assume that there is a positive relationship between the predictor and the outcome. However, the t value is 1.360 and sig. of .179 > .05 means that the predictor is not making significant contribution.

For company factor there is a negative coefficient (-.141) and represents a negative relationship between the predictor. The t value is -.861 and sig of .393 > .05 means that the predictor is not making significant contribution.

The industry factor has positive values (.296) and is an indicator of positive relationship between Lean designs understanding predictor. The t factor value is 1.989 and with sig. of .052 is said to be making some contribution.

Lean Application and Adoption in design and product / materials development process = 1.268 + .296* Industrial + .191* Regulatory + (-.141*Company).

5.12.4. Innovative Operational Efficiencies

H4: the company, industrial and regulatory factors positively affect innovative production/operational efficiencies

In Table 5.32 innovative production/operational efficiencies are poorly related to regulatory (0.284) factors and the significance value is .027 > .01; somewhat related to industrial (0.016) factors and the significance value is .0904 > .01; and related to company (0.422) factors and the significance value is .001 < .01.

Correlations					
		Innovative operational efficiencies	Company Factors	Industry Factors	Regulatory Factors
Innovative operational efficiencies	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	**.422****	1		
	Sig. (2-tailed)	0.001			
	N	61	61		
Industry Factors	Pearson Correlation	**0.016**	**.523****	1	
	Sig. (2-tailed)	0.904	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	**.284***	**.431****	**0.135**	1
	Sig. (2-tailed)	0.027	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

Table 5.32 Correlation between Company, Industrial and Regulatory factors and innovative operational efficiencies

Model Summary										
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**					**Durbin-Watson**
					R Square Change	**F Change**	**df1**	**df2**	**Sig. F Change**	
1	**.493[a]**	**0.243**	**0.204**	**0.612**	**0.243**	**6.114**	**3**	**57**	**0.001**	**1.763**
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Innovative operational efficiencies										

Table 5.33 Correlation between Company, Industrial and Regulatory factors and innovative operational efficiencies

In this model summary, the coefficient of correlation (R) is .493 while coefficient of determination (R square) is .243. In Table 5.33 this means that the company, industrial and organisational variables explain about 24.3% of the change in: innovative production/operational efficiencies. That is the independent variables explain 24.3% of variation in the innovative operational efficiencies.

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	**6.875**	**3**	**2.292**	**6.114**	**.001[b]**
	Residual	**21.366**	**57**	**.375**		
	Total	**28.241**	**60**			
a. Dependent Variable: Innovative operational efficiencies						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.34 Analysis of variance on innovative operational efficiencies

The difference between the R square and adjusted R square means that the model would account 3.9% (.243 - .204) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .612; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.763 which is not more than 2.0 and indicates that the assumption of independent error has been met.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.106	0.764		1.448	0.153
	Company Factors	0.848	0.243	0.523	3.496	0.001
	Industry Factors	-0.536	0.27	-0.271	-1.99	0.052
	Regulatory Factors	0.146	0.197	0.096	0.743	0.46
a. Dependent Variable: Innovative operational efficiencies						

Table 5.35 Coefficients – Innovative operational efficiencies

For this model, ANOVA, the F-test (6.114), Table 5.34, confirms to us that the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is .001 < .05, so we can reject the null hypothesis that the model has no predictive value.

The first coefficient (Constant = 1.106) is intercept term, Table 5.35. In this case, the intercept is 1.106, so when X=0, Y will equal 1.106 (regression equations Y = b0 + b1x1).

The B values tell us about the relationship between innovative operational efficiencies and each predictor. For the regulatory factor the value is positive (0.096). We can assume that there is a positive relationship between the predictor and the outcome. However, the t value is 0.743 and sig. of 0.46 < .05 means that the regulatory factor is not making significant contribution.

For company factor there is a positive coefficient (0.523) and represents a negative relationship between the predictor. The t value is 3.496 and sig of .001 < .05 means that the predictor is making significant contribution.

The industry factor has negative values (-0.271) and is an indicator of negative relationship between innovative operational efficiencies predictor. The t factor value is -1.99 and with sig. of .052 is said to be making some contribution.

Innovative production/operational efficiencies = 1.106 + (-0.271)* Industrial + 0.096 * Regulatory + 0.523*Company.

5.12.5. Impact of Economic Environment on Product Innovation

H5: the company, industrial and regulatory factors positively influence through economic environment on product innovation process

Correlations					
		Impact of Economic Environment on Product Innovation Process	Company Factors	Industry Factors	Regulatory Factors
Impact of Economic Environment on Product Innovation Process	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	**0.204**	1		
	Sig. (2-tailed)	0.115			
	N	61	61		
Industry Factors	Pearson Correlation	**0.112**	**.523****	1	
	Sig. (2-tailed)	0.39	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	**0.079**	**.431****	**0.135**	1
	Sig. (2-tailed)	0.546	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.36 Correlation between Company, Industrial and Regulatory factors and impact on product innovation process

The SPSS output Table 5.36 provides a matrix of correlation coefficients for the three variables - company, industrial and regulatory. Underneath each correlation coefficient both the significance value of the correlation and the sample size (N) on which it is based are displayed. Each variable is perfectly correlated with itself and r = 1 along the diagonal of the table.

Impact of Economic Environment on Product Innovation Process activities are positively related to industrial factors (0.112), the significance value is.39 > .01, which tells us that there is no strong relationship between variables. For the company factors (.204), the significance level is 0.115 > .01, meaning there is poor relationship between variables. For the regulatory factors (0.079), the significance level is 0.546>.01 and therefore there is poor relationship between the variables.

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.204[a]	0.042	-0.009	0.691	0.042	0.828	3	57	0.484	1.766
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Impact of Economic Environment on Product Innovation Process										

Table 5.37 Model Summary on product innovation process

In this model summary, Table 5.37, the coefficient of correlation (R) is .204 while coefficient of determination (R square) is .042. This means that the company, industrial and organisational variables explain about 4.2% of the change in 'Impact of Economic Environment on Product Innovation Process'. That is the independent variables explain 4.2% of variation in 'Impact of Economic Environment on Product Innovation Process'. The difference between the R square and adjusted R square means that the model would account 5.1% [.042 – (- .009)] or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .691; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.766 which is not off than 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.185	3	.395	.828	.484[b]
	Residual	27.204	57	.477		
	Total	28.389	60			
a. Dependent Variable: Impact of Economic Environment on Product Innovation Process						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.38 Analysis of variance on product innovation process

In Table 5.38, for this model, ANOVA, the F-test (.828), confirms to us that the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is .484 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.833	0.862		2.126	0.038
	Company Factors	0.334	0.274	0.205	1.22	0.227
	Industry Factors	0.012	0.304	0.006	0.039	0.969
	Regulatory Factors	-0.016	0.222	-0.01	-0.07	0.943
a. Dependent Variable: Impact of Economic Environment on Product Innovation Process						

Table 5.39 Coefficients – Product innovation process

The first coefficient (Constant = 1.833) is intercept term, Table 5.39. In this case, the intercept is 1.833, so when X=0, Y will equal 1.833 (regression equations Y = b0 + b1x1).

The B values tell us about the relationship between Impact of Economic Environment on Product Innovation Process and each predictor.

For the regulatory factor the Beta value is positive (-.001). We can assume that there is a negative relationship between the predictor and the outcome. However, the t value is -.07 and sig. of .943 > .05 means that the predictor is not making significant contribution.

For company factor there is a positive coefficient (.205) and represents a negative relationship between the predictor. The t value is 1.22 and sig of .227 > .05 means that the predictor is not making significant contribution.

The industry factor has positive values (.006) and is an indicator of positive relationship between Lean designs understanding predictor. The t factor value is .039 and with sig. of .969 > .05, it is clear that it is not making significant contribution.

Impact of Economic Environment on Product Innovation Process = 1.833 + .205* Company + .006* Industrial + (-0.01*Regulatory).

5.12.6. Impact of Organisational Processes and Management Practices on Supply Chain

H6: the company, industrial and regulatory factors positively influence Impact of Organisational Processes and Management Practices on Supply Chain

Correlations					
		Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	Company Factors	Industry Factors	Regulatory Factors
Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	0.001	1		
	Sig. (2-tailed)	0.997			
	N	61	61		
Industry Factors	Pearson Correlation	0.001	.523**	1	
	Sig. (2-tailed)	0.995	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	0.129	.431**	0.135	1
	Sig. (2-tailed)	0.321	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.40 Correlation between Company, Industrial and Regulatory factors and management practices on supply chain

Impact of organisational processes and management practices on supply chain in your organisation process activities are positively related to industrial factors (r = .041, significance = .753), the significance value is.753 > .01, which tells us that there is almost no relationship between variables; for the company factors (.001), the significance level is 0.997 > .01, means there is virtually no relationship between variables; and for the regulatory factors (0.129) , the significance level 0.321>.01 and therefore means there is a poor relationship between the variables, Table 5.40.

Model Summary										
				Std. Error of the Estimate	Change Statistics					
Model	R	R Square	Adjusted R Square		R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.144[a]	0.021	-0.031	0.325	0.021	0.402	3	57	0.752	1.731
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Impact of Organisational Processes and Management Practices on Supply Chain in your organisation										

Table 5.41 Model Summary on supply chain

In this model summary, Table 5.41, the coefficient of correlation (R) is .144 while coefficient of determination (R square) is .021. This means that the company, industrial and organisational variables explain about 2.1% of the change in: 'Impact of Organisational Processes and Management Practices on Supply Chain in your organisation'. That is the independent variables explain 2.1% of variation in 'Impact of Organisational Processes and Management Practices on Supply Chain in your organisation'. The difference between the R square and adjusted R square means that the model would account 3.1% [.021 – (- .031)] or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .325; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the

Durbin Watson statistics is 1.731 which is not off than 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.128	3	.043	.402	.752[b]
	Residual	6.030	57	.106		
	Total	6.158	60			
a. Dependent Variable: Impact of Organisational Processes and Management Practices on Supply Chain in your organisation						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.42 Analysis of variance on supply chain

For this model, Table 5.42 ANOVA, the F-test (.402), confirms to us that the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is 0.752 > 0.05, so we cannot reject the null hypothesis that the model has no predictive value.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.935	0.406		7.231	0
	Company Factors	-0.06	0.129	-0.079	-0.467	0.642
	Industry Factors	0.019	0.143	0.021	0.133	0.894
	Regulatory Factors	0.115	0.105	0.161	1.099	0.276
a. Dependent Variable: Impact of Organisational Processes and Management Practices on Supply Chain in your organisation						

Table 5.43 Coefficients – Supply Chain

In Table 5.43, the first coefficient (Constant = 2.935) is intercept term. In this case, the intercept is 2.935, so when X=0, Y will equal 2.35 (regression equations Y = b0 + b1x1).

The B values tell us about the relationship between 'Impact of Organisational Processes and Management Practices on Supply Chain in your organisation and each predictor'.

For the regulatory factor the value is positive (.115). We can assume that there is a positive relationship between the predictor and the outcome. However, the t value is (1.099) and sig. of .276 > .05 means that the predictor is not making significant contribution.

For company factor there is a negative coefficient (-.06) and represents a negative relationship between the predictor. The t value is -.467 and sig of .642 > .05 means that the predictor is not making significant contribution.

The industry factor has positive values (.019) and is an indicator of positive relationship between the predictor and outcome. The t factor value is .133 and with sig. of .894 > .05 is said to be not making significant contribution.

Impact of Organisational Processes and Management Practices on Supply Chain in your organisation = 2.935 + (-0.079* Company) + 0.021* Industrial + (0.161*Regulatory).

5.12.7. Customer Engagement Practices

H7: the company, industrial and regulatory factors positively Impact customer engagement practices

Customer engagement practices are positively related to industrial factors (0.165). Table 5.44 shows that the significance value is.204 > .01, meaning there is not a poor relationship between variables. For the company factors (0.192), the significance level is 0.137 > .01, meaning there is not a significant relationship between variables; and for the regulatory factors (-0.123), the significance level 0.346>.01 and therefore there is poor relationship between the variables.

Correlations					
		Customer engagement practices	Company Factors	Industry Factors	Regulatory Factors
Customer engagement practices	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	0.192	1		
	Sig. (2-tailed)	0.137			
	N	61	61		
Industry Factors	Pearson Correlation	0.165	.523**	1	
	Sig. (2-tailed)	0.204	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	-0.123	.431**	0.135	1
	Sig. (2-tailed)	0.346	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.44 Correlation between Company, Industrial and Regulatory factors and impact on customer engagement practices

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.302[a]	0.091	0.044	0.511	0.091	1.91	3	57	0.138	2.041
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: customer engagement practices										

Table 5.45 Model Summary on customer engagement practices

In this model summary, Table 5.45, the coefficient of correlation (R) is .302 while coefficient of determination (R square) is .091. This means that the company, industrial and organisational variables explain about 9.1% of the change in: customer engagement practices. That is the independent variables explain 9.1% of variation in the Customer Engagement Practices. The difference between the R square and adjusted R square means that the model would account for 4.7% (.091 – .044) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .511; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.041 which is not off than 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	**1.495**	**3**	**.498**	**1.910**	**.138[b]**
	Residual	**14.876**	**57**	**.261**		
	Total	**16.371**	**60**			
a. Dependent Variable: Customer Engagement Practices						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.46 Analysis of variance on customer engagement practices

For this model, Table 5.46 ANOVA, the F-test (1.910), confirms to us that the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is .138 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.912	0.638		4.568	0
	Company Factors	0.331	0.203	0.268	1.636	0.107
	Industry Factors	0.087	0.225	0.058	0.389	0.699
	Regulatory Factors	-0.287	0.164	-0.246	-1.75	0.086
a. Dependent Variable: Customer Engagement Practices						

Table 5.47 Coefficients – Customer Engagement Practices

The first coefficient (Constant = 2.912) is intercept term, Table 5.47. In this case, the intercept is 2.912, so when X=0, Y will equal 2.912 (regression equations Y = b0 + b1x1).

The B values tell us about the relationship between Customer Engagement Practices and each predictor. For the regulatory factor the value is negative (-.246). We can assume that there is a negative relationship between the predictor and the outcome. However, the t value is -1.75 and sig. of .086 > .05 means that the predictor is making some contribution.

For company factor there is a positive coefficient (.268) and represents a positive relationship between the predictor. The t value is 1.636 and sig of .107 > .05 means that the predictor is making some contribution.

The industry factor has positive values (.058) and is an indicator of positive relationship between the predictor and outcome. The t factor value is .389 and with sig. of .699 > .05 is said to be making some contribution.

Customer Engagement Practices = 2.912 + .268* Company + .058* Industrial + (-.246*Regulatory).

5.12.8. Impact Commitment from all Departments

H8: the company, industrial and regulatory factors positively Impact supply chain management practices

In Table 5.48, supply chain commitment from all departments practices are positively related to industrial factors (0.022). The significance value, which is.867 > .01, tells us that there is almost no relationship between variables since the significance level is almost 1. For the company factors (0.19), the significance level is 0.143 > .01, meaning there is some relationship between variables; and for the regulatory factors (0.099), the significance level is 0.45>.01 and therefore there is some relationship between the variables

Correlations					
		Supply chain commitment from all departments	Company Factors	Industry Factors	Regulatory Factors
Supply chain commitment from all departments	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	0.19	1		
	Sig. (2-tailed)	0.143			
	N	61	61		
Industry Factors	Pearson Correlation	0.022	.523**	1	
	Sig. (2-tailed)	0.867	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	0.099	.431**	0.135	1
	Sig. (2-tailed)	0.45	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.48 Correlation between Company, Industrial and Regulatory factors and impact commitment from all departments

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Model Summary										
Model	**R**	**R Sqr.**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**					**Durbin-Watson**
					R Square Change	**F Change**	**df1**	**df2**	**Sig. F Change**	
1	**.210[a]**	**0.044**	**-0.006**	**0.642**	**0.044**	**0.879**	**3**	**57**	**0.457**	**2.021**
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Supply chain commitment from all departments										

Table 5.49 Model Summary on supply chain commitment from all departments

In this model summary, Table 5.49, the coefficient of correlation (R) is .210 while coefficient of determination (R square) is .044. This means that the company, industrial and organisational variables explain about 4.4% of the change in 'Supply chain commitment from all departments'. That is the independent variables explain

4.4% of variation in supply chain commitment from all departments. The difference between the R square and adjusted R square means that the model would account 5.0% [.044 – (.006)] or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .642; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.021 which is almost 2.0 and indicates that the assumption of independent error has been met.

For this model, Table 5.50 ANOVA, the F-test (.879), confirms that the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is .457 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

ANOVA[a]						
Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	**1.087**	**3**	**.362**	**.879**	**.457[b]**
	Residual	**23.488**	**57**	**.412**		
	Total	**24.575**	**60**			
a. Dependent Variable: Supply chain commitment from all departments						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.50 Analysis of variance on supply chain commitment from all departments

The first coefficient (Constant = 2.342) is intercept term (Table 5.51). In this case, the intercept is 2.342, so when X=0, Y will equal 2.912 (regression equations Y = b0 + b1x1). The B values tell us about the relationship between supply chain commitment from all departments and each predictor.

For the regulatory factor the value is positive (0.09) we can assume that there is a positive relationship between the predictor and the outcome. However, the t value is (.063) and sig. of .95 > .05, at almost 1.0, meaning the predictor is making little or no contribution.

For company factor there is a positive coefficient (0.241) and represents a positive relationship between the predictor. The t value is 1.433 and sig of .157 > .05 means that the predictor is making some contribution.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.342	0.801		2.923	0.005
	Company Factors	0.365	0.254	0.241	1.433	0.157
	Industry Factors	-0.195	0.283	-0.105	-0.688	0.494
	Regulatory Factors	0.013	0.206	0.009	0.063	0.95
a. Dependent Variable: Supply chain commitment from all departments						

Table 5.51 Coefficients – Supply chain commitment from all departments

The industry factor which has a negative value (-.105), indicates a negative relationship between the predictor and outcome. The t factor value is -.688 and with sig. of .494 > .05, means it is making some contribution.

Supply chain commitment from all departments = 2.342 + 0.241* Company + (-0 .105* Industrial) + 0.009*Regulatory).

5.12.9. Innovative Marketing

H9: the company, industrial and regulatory factors positively influence innovative Marketing

Innovative marketing practices are negatively related to industrial factors (-0.22). The significance value which is .089 > .01 (Table 5.52), tells us that there is a negative relationship between variables. For the company factors (-0.214), the significance level is 0.098 > .01, meaning there is a negative relationship between variables; and for the regulatory factors (0.164), the significance level is 0.207>.01. Therefore, there is some relationship between the variables

Correlations					
		Innovative Marketing	Company Factors	Industry Factors	Regulatory Factors
Innovative Marketing	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	-0.214	1		
	Sig. (2-tailed)	0.098			
	N	61	61		
Industry Factors	Pearson Correlation	-0.22	.523**	1	
	Sig. (2-tailed)	0.089	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	0.164	.431**	0.135	1
	Sig. (2-tailed)	0.207	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.52 Correlation between Company, Industrial and Regulatory factors and innovative marketing

.In this model summary, the coefficient of correlation (R) is .367 while coefficient of determination (R square) is .135. This means that the company, industrial and organisational variables explain about 13.5% of the change in innovative marketing (Table 5.53). That is the independent variables explain 13.5% of variation in innovative marketing

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.367[a]	0.135	0.089	0.669	0.135	2.966	3	57	0.04	2.276
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Innovative Marketing										

Table 5.53 Model Summary on innovative Marketing.

The difference between the R square and adjusted R square means that the model would account for 4.6% (0.135 – .089) or less variance in the outcome if derived from population rather than a sample.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.987	3	1.329	2.966	.040[b]
	Residual	25.543	57	.448		
	Total	29.530	60			
a. Dependent Variable: Innovative Marketing						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.54 Analysis of variance on innovative marketing

The standard error of estimate for the model is 0.669; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.276 which is not too far off 2.0 and indicates that the assumption of independent error has been met (Table 5.54).

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.562	0.835		4.264	0
	Company Factors	-0.475	0.265	-0.286	-1.79	0.079
	Industry Factors	-0.224	0.295	-0.111	-0.76	0.45
	Regulatory Factors	0.473	0.215	0.302	2.197	0.032
a. Dependent Variable: Innovative Marketing						

Table 5.55 Coefficients – Innovative Marketing

For this model, ANOVA, the F-test (2.966), confirms that the model can predict key elements of the supply chain practices using the 'Company, Industrial and

Organisational' factors. The significance is .040 < .05, so we can reject the null hypothesis that the model has no predictive value.

In Table 5.55, the first coefficient (Constant = 3.562) is intercept term. In this case, the intercept is 3.562, so when X=0, Y will equal 3.562 (regression equations Y = b0 + b1x1). The B values tell us about the relationship between Innovative Marketing and each predictor.

For the regulatory factor the value is positive (0.302), so we can assume that there is a positive relationship between the predictor and the outcome. However, the t value which is 2.197 and sig. of .032 < .05, means that the predictor is making significant contribution.

For company factor there is a negative coefficient (-0.286) and represents a positive relationship between the predictor. The t value is (-1.79) and sig of .079 > .05, means that the predictor is making some contribution.

The industry factor which has a negative value of -0.111, indicates a negative relationship between the predictor and outcome. The t factor value is (-.76) and with sig. of .45 > .05, some contribution has been registered.

Innovative Marketing = 3.562 + (-0.286* Company + (-0 .111* Industrial) + 0.302*Regulatory).

5.12.10. Using nearby Supply Chain Sources

Hypothesis 10: the company, industrial and regulatory factors positively affect use of reverse logistics practice

Performance measures practices are positively related to industrial factors (0.192), in Table 5.56, the significance value is.138 > .01, which tells us that there is some relationship between variables. For the company factors (0.313), the significance level is 0.014 > .01, meaning there is relationship between variables. For the regulatory factors (-0.007), the significance level is 0.96>.01, at almost 1.0. Therefore, there is no relationship between the variables.

Correlations					
		Performance measures	Company Factors	Industry Factors	Regulatory Factors
Performance measures	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	.313*	1		
	Sig. (2-tailed)	0.014			
	N	61	61		
Industry Factors	Pearson Correlation	0.192	.523**	1	
	Sig. (2-tailed)	0.138	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	-0.007	.431**	0.135	1
	Sig. (2-tailed)	0.96	0.001	0.3	
	N	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.56 Correlation between Company, Industrial and Regulatory factors and use of reverse logistics practice

Model Summary										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.253[a]	0.064	0.015	0.413	0.064	1.297	3	57	0.284	2.059
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Use of reverse logistics Practices										

Table 5.57 Model Summary on use of reverse logistics practices

In this model summary (Table 5.57), the coefficient of correlation (R) is .253 while coefficient of determination (R square) is 0.064. This means that the company, industrial and organisational variables explain about 6.4% of the change in ‘use of reverse logistics practices’. That is the independent variables explain 6.4% of variation in 'use of reverse logistics practices'. The difference between the R square and adjusted R square means that the model would account for 4.9% (.064 – .015) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .413. This is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.059 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.663	3	.221	1.297	.284[b]
	Residual	9.714	57	.170		
	Total	10.377	60			
a. Dependent Variable: Use of reverse logistics Practices						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.58 Analysis of variance on reverse logistics practices

For this model (Table 5.58 ANOVA), the F-test (1.297), confirms that the model can predict key elements of the supply chain practices using the 'Company, Industrial and Organisational' factors. The significance is .284 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.022	0.515		5.867	0
	Company Factors	0.152	0.164	0.155	0.931	0.356
	Industry Factors	0.094	0.182	0.079	0.519	0.606
	Regulatory Factors	-0.224	0.133	-0.242	-1.69	0.097
a. Dependent Variable: Use of reverse logistics Practices						

Table 5.59 Coefficients – Use of reverse logistics practices

The first coefficient (Constant = 3.022) is intercept term. In this case, the intercept is 3.022, so when X=0, Y will equal 3.022 (regression equations Y = b0 + b1x1) (Table 5.59).

The B values tell us about the relationship between 'Use of reverse logistics Practices' and each predictor. For the regulatory factor the value is negative (-0.242). We can assume that there is a negative relationship between the predictor and the outcome. However, the t value is -1.69 and sig. of .097 > .05 means that the predictor is making some contribution.

For company factor there is a positive coefficient (0.155) and represents a positive relationship between the predictor. The t value is 0.931 and sig of .356 > .05 means that the predictor is making some contribution.

The industry factor has positive values (0.079) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.519 and with sig. of .606 > .05, it is acknowledged to be making some contribution.

Use of reverse logistics Practices = 3.022 + 0.155* Company + 0 .079* Industrial) + (-0.242*Regulatory)

5.12.11. Semi-Automated Equipment Adoption

H11: the company, industrial and regulatory factors positively affect Semi-automated equipment adoption

In Table 5.60, semi-automated safety quality practices are positively related to industrial factors (0.042), the significance value is 0.749 > .01, which tells us that there is a very poor relationship between variables. For the company factors (0.296), the significance level is 0.021 > .01, meaning there is some relationship between variables. For the regulatory factors (0.177), the significance level of 0.171>.01 and therefore there is a poor relationship between the variables.

Correlations					
		Semi-automated safety quality	Company Factors	Industry Factors	Regulatory Factors
Semi-automated safety quality	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	.296*	1		
	Sig. (2-tailed)	0.021			
	N	61	61		
Industry Factors	Pearson Correlation	0.042	.523**	1	
	Sig. (2-tailed)	0.749	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	0.177	.431**	0.135	1
	Sig. (2-tailed)	0.171	0.001	0.3	
	N	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.60 Correlation between Company, Industrial and Regulatory factors and semi-automated equipment adoption

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.326[a]	0.107	0.06	0.749	0.107	2.267	3	57	0.09	1.722
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Semi-automated safety quality										

Table 5.61 Model Summary on semi-automated equipment adoption

In this model summary (Table 5.61), the coefficient of correlation (R) is .326 while coefficient of determination (R square) is .107. This means that the company, industrial and organisational variables explain about 10.7% of the change in 'semi-automated equipment adoption'. That is, the independent variables explain 10.7% of variation in the semi-automated equipment adoption. The difference between the R square and adjusted R square means that the model would account 4.7% (.107 – .06) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .749. This is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.722 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.814	3	1.271	2.267	.090[b]
	Residual	31.971	57	.561		
	Total	35.785	60			
a. Dependent Variable: Semi-automated safety quality						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.62 Analysis of variance on semi-automated equipment adoption

For this model (Table 5.62 ANOVA), the F-test (2.267), confirms to us that the model can predict key elements of the supply chain practices using the Company, Industrial and Organisational factors. The significance is .091 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

The first coefficient (Constant = 2.18) is intercept term. In this case, the intercept is 2.18, so when X=0, Y will equal 2.18 (regression equations Y = b0 + b1x1). The B values tell us about the relationship between 'Semi-automated safety quality' and each predictor (Table 5.63).

For the regulatory factor the value is positive (0.045). So, we can assume that there is a positive relationship between the predictor and the outcome. However, the t value is 0.321 and sig. of .75 > .05, means that the predictor is making some contribution.

Coefficients						
Model		Un-standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.18	0.935		2.332	0.023
	Company Factors	0.649	0.297	0.355	2.184	0.033
	Industry Factors	-0.334	0.33	-0.15	-1.013	0.315
	Regulatory Factors	0.077	0.241	0.045	0.321	0.75
a. Dependent Variable: Semi-automated safety quality						

Table 5.63 Coefficients – Semi-automated equipment adoption

For company factor there is a positive coefficient (0.355) and represents a positive relationship between the predictor. The t value is 2.184 and sig of .033 < .05 means that the predictor is making a significant contribution.

The industry factor has negative values (-0.15) and indicates negative relationship between the predictor and outcome. The t factor value is -1.013 and with sig. of .315 > .05, the predictor is not making a significant contribution.

Semi-automated equipment adoption = 2.18 + 0.355* Company + (-0 .15* Industrial) + (0.045*Regulatory)

5.12.12. Lean Adoption and Application in Supply Chain

H12: the company, industrial and regulatory factors positively affect Lean Adoption and Application in Supply Chain

In Table 5.64, lean Adoption and Application in Supply Chain practices are positively related to industrial factors (0.125), the significance value is 0.336 > .01, which tells us that there is a poor relationship between variables. For the company factors (0.379), the significance level is 0.003 > .01, meaning there is a relationship between variables. For the regulatory factors (0.148), the significance level 0.225>.01 and therefore there is some relationship between the variables.

Therefore, it can be said that there is a complex relationship between the variables.

Correlations					
		Lean Adoption and Application in Supply Chain	Company Factors	Industry Factors	Regulatory Factors
Lean Adoption and Application	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	.379**	1		
	Sig. (2-tailed)	0.003			
	N	61	61		
Industry Factors	Pearson Correlation	0.125	.523**	1	
	Sig. (2-tailed)	0.336	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	0.148	.431**	0.135	1
	Sig. (2-tailed)	0.255	0.001	0.3	
	N	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.64 Correlation between Company, Industrial and Regulatory factors and lean adoption and application in supply chain

Model Summary										
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**					**Durbin-Watson**
					R Square Change	**F Change**	**df1**	**df2**	**Sig. F Change**	
1	**.390[a]**	**0.152**	**0.107**	**0.348**	**0.152**	**3.406**	**3**	**57**	**0.024**	**1.774**
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Lean Adoption and Application in Supply Chain										

Table 5.65 Model Summary on lean adoption and application in supply chain

In this model summary (Table 5.65), the coefficient of correlation (R) is .390 while coefficient of determination (R square) is .0.152. This means that the company, industrial and organisational variables explain about 15.2% of the change in 'Lean Adoption and application in supply chain'. That is, the independent variables explain

15.2% of variation in 'Lean Adoption and application in supply chain'. The difference between the R square and adjusted R square means that the model would account 4.5% (.152 – .107) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .481. This is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.774 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.238	3	.413	3.406	.024[b]
	Residual	6.905	57	.121		
	Total	8.143	60			
a. Dependent Variable: Lean Adoption and Application in Supply Chain						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.66 Analysis of variance on lean adoption and application in supply chain

For this model (Table 5.66 ANOVA), the F-test (3.406), confirms that the model can predict key elements of the supply chain practices using the 'Company, Industrial and Organisational factors'. The significance is .024 < .05, so we can reject the null hypothesis that the model has no predictive value.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.436	0.434		5.609	0
	Company Factors	0.39	0.138	0.447	2.826	0.006
	Industry Factors	-0.111	0.153	-0.105	-0.726	0.471
	Regulatory Factors	-0.025	0.112	-0.031	-0.224	0.823
a. Dependent Variable: Lean Adoption and Application in Supply Chain						

Table 5.67 Coefficients – Lean Adoption and Application in Supply Chain

In Table 5.67, the first coefficient (Constant = 2.436) is intercept term. In this case, the intercept is 2.436, so when X=0, Y will equal 2.436 (regression equations Y = b0 + b1x1). The B values tell us about the relationship between 'Lean Adoption and application in supply chain' and each predictor.

For the regulatory factor the value is negative (-0.031). So, we can assume that there is a negative relationship between the predictor and the outcome. However, the t value is (0.224) and sig. of .823 > .05 means that the predictor is making little or no contribution.

For company factor there is a positive coefficient (0.447) and represents a positive relationship between the predictor. The t value is 2.826 and sig of .006 < .05 means that the predictor is making significant contribution.

The industry factor has negative values (-0.105) and is an indicator of negative relationship between the predictor and outcome. The t factor value is .726 and with sig. of .471 > .05, the predictor is said to be not making significant contribution.

Lean Adoption and Application in Supply Chain = 2.436 + 0.447* Company + (-0 .105* Industrial) + (-0.031*Regulatory).

5.12.13. Lean Adoption in Supply Chain of Product Development

H13: the company, industrial and regulatory factors positively affect Lean Adoption in Supply Chain of Product Production Process

It is evident from Table 5.68 that 'Lean Adoption in Supply Chain of Product Production Process practices' are positively related to industrial factors (0.295). The significance value is 0.021 > .01, which tells us that there is a poor relationship between variables. For the company factors (0.248), the significance level is 0.054 > .01, meaning there is poor relationship between variables. For the regulatory factors (0.209), the significance level is 0.106>.01 and therefore there is some relationship between the variables.

Correlations					
		Lean Adoption in Supply Chain of Product Production Process	Company Factors	Industry Factors	Regulatory Factors
Lean Adoption in Supply Chain of Product Production Process	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	61			
Company Factors	Pearson Correlation	0.248	1		
	Sig. (2-tailed)	0.054			
	N	61	61		
Industry Factors	Pearson Correlation	.295*	.523**	1	
	Sig. (2-tailed)	0.021	0		
	N	61	61	61	
Regulatory Factors	Pearson Correlation	0.209	.431**	0.135	1
	Sig. (2-tailed)	0.106	0.001	0.3	
	N	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5.68 Correlation between Company, Industrial and Regulatory factors and lean adoption in supply chain of product production process

Model Summary[b]										
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**					**Durbin-Watson**
					R Square Change	**F Change**	**df1**	**df2**	**Sig. F Change**	
1	**.343[a]**	**.118**	**.071**	**.592**	**.118**	**2.538**	**3**	**57**	**.066**	**1.886**
a. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors										
b. Dependent Variable: Lean Adoption in Supply Chain of Product Production Process										

Table 5.69 Model Summary on lean adoption in supply chain of product production process

In this model summary (Table 5.69) the coefficient of correlation (R) is 0.343 while coefficient of determination (R square) is 0.118. This means that the company, industrial and organisational variables explain about 11.8% of the change in 'Lean Adoption in Supply Chain of Product Production Process'. That is, the independent variables explain 11.8% of variation in 'Lean Adoption in Supply Chain of Product Production Process'. The difference between the R square and adjusted R square means that the model would account for 4.7% (.118 – .071) or less variance in the outcome, if derived from population rather than a sample. The standard error of estimate for the model is .592. This is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.886 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.673	3	.891	2.538	.066[b]
	Residual	20.010	57	.351		
	Total	22.683	60			
a. Dependent Variable: Lean Adoption in Supply Chain of Product Production Process						
b. Predictors: (Constant), Regulatory Factors, Industry Factors, Company Factors						

Table 5.70 Analysis of variance on lean adoption in supply chain of product production process

For this model (Table 5.70 ANOVA) the F-test (2.538), confirms that the model can predict key elements of the supply chain practices using the 'Company, Industrial and Organisational factors'. The significance is .066 > .05, so we can reject the null hypothesis that the model has no predictive value.

The first coefficient (Constant = 1.153) is intercept term. In this case, the intercept is 1.153, so when X=0, Y will equal 1.153 (regression equations Y = b0 + b1x1). The B values tell us about the relationship between 'Lean Adoption in Supply Chain of Product Production Process' and each predictor (Table 5.71).

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.153	.739		1.560	.124
	Company Factors	.077	.235	.053	.329	.743
	Industry Factors	.437	.261	.246	1.675	.099
	Regulatory Factors	.210	.191	.153	1.103	.275
a. Dependent Variable: Lean Adoption in Supply Chain of Product Production Process						

Table 5.71 Coefficients – Lean Adoption in Supply Chain of Product Production Process

For the regulatory factor the value is positive (0.153), so we can assume that there is a positive relationship between the predictor and the outcome. However, the t value is (1.103) and sig. of .275 > .05 means that the predictor is making little or no contribution.

For company factor there is a positive coefficient (.053) and represents a positive relationship between the predictor. The t value is .329 and sig of .743 < .05 means that the predictor is making little or no contribution.

The industry factor has positive values (.246) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.675 and with sig. of .099 > .05, the predictor is making some contribution.

Lean Adoption in Supply Chain of Product Production Process = 1.153 +.053* Company + .246* Industrial) + 0.153*Regulatory).

5.13. Key Organisational Practices Impacting the Performance of the Organisation

This part of the Chapter, analyses the impact of some of the key organisational practices on the performance of the organisation.

5.13.1 Business Efficiencies

In this section the relationship between organisational practices and their impacts on business efficiencies are examined.

Hypothesis 14: Key organisational practices positively influence improvements in Business efficiencies

The following findings from Table 5.72 are worth noting:

- Key elements of innovative supply chain practices is somewhat related to improved business efficiencies (.232) and significance value is .072 >.01.
- Innovative product design practices are very poorly related to improved business efficiencies (.012). The significance value is .924 >.01.
- Lean application and adoption in design and product/materials development process practices is somewhat related to improved business efficiencies (.127) and significance value is .329 >.01.
- Innovative products production/operations practices are somewhat related to improved business efficiencies (.140). The significance value is .281 >.01.
- Customer engagement practices is somewhat related to improved business efficiencies (.048). The significance value is .711 >.01.
- Innovative supply chain management practices are somewhat related to improved business efficiencies (.153). The significance value is .238 >.01.
- Innovative marketing practices is somewhat negatively related to improved business efficiencies (-.150) and the significance value is .247 >.01.
- Using nearby supply chain sources practices is somewhat related to improved business efficiencies (.063) and the significance value is .630 >.01.
- Use of reverse logistics practices is somewhat related to improved business efficiencies (.093) and the significance value is .478 >.01.
- Lean adoption and application practices is somewhat related to improved business efficiencies (.291) and the significance value is .023 >.01.
- Lean adoption in supply chain of product production process practices is somewhat related to improved business efficiencies (.072) and the significance value is.581>.01.

Correlations													
		Improved Business Efficiencies	Key elements of Innovative supply chain practices	Innovative Product Design Practices	Lean Application and Adoption in design and product / materials	Innovative Products Production/Operations Practices	Customer Engagement Practices	Innovative Supply Chain Management Practices	Innovative Marketing Practices	Using nearby supply chain sources	Use of reverse logistics Practices	Lean Adoption and Application in	Lean Adoption in Supply Chain of Product Production
Improved Business Efficiencies	Pearson Correlation	1	.232	.012	.127	.140	.048	.153	-.150	.063	.093	.291*	.072
	Sig. (2-tailed)		.072	.924	.329	.281	.711	.238	.247	.630	.478	.023	.581
	N	61	61	61	61	61	61	61	61	61	61	61	61
Key elements of Innovative supply chain practices	Pearson Correlation	.232	1	-.137	-.075	.036	.069	.249	-.100	-.065	-.088	.037	-.074
	Sig. (2-tailed)	.072		.291	.566	.780	.596	.053	.445	.619	.502	.777	.570
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Product Design Practices	Pearson Correlation	.012	-.137	1	.204	.198	.274*	.088	.136	.089	.195	.181	.215
	Sig. (2-tailed)	.924	.291		.115	.127	.033	.502	.296	.494	.133	.163	.096
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Application and Adoption in design and product / materials development process	Pearson Correlation	.127	-.075	.204	1	.150	-.225	.088	.051	.157	.088	.080	.144
	Sig. (2-tailed)	.329	.566	.115		.249	.081	.498	.697	.228	.501	.539	.270
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Products Production/Operations Practices	Pearson Correlation	.140	.036	.198	.150	1	.256*	.239	.035	.189	.373**	.211	.426**
	Sig. (2-tailed)	.281	.780	.127	.249		.047	.064	.791	.144	.003	.103	.001
	N	61	61	61	61	61	61	61	61	61	61	61	61
Customer Engagement Practices	Pearson Correlation	.048	.069	.274*	-.225	.256*	1	.190	-.099	.097	.194	.107	.216
	Sig. (2-tailed)	.711	.596	.033	.081	.047		.143	.447	.455	.133	.411	.094
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Supply Chain Management Practices	Pearson Correlation	.153	.249	.088	.088	.239	.190	1	.034	.154	-.009	.230	.117
	Sig. (2-tailed)	.238	.053	.502	.498	.064	.143		.798	.237	.945	.074	.368

	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Marketing Practices	Pearson Correlation	-.150	-.100	.136	.051	.035	-.099	.034	1	-.014	.104	.046	-.083
	Sig. (2-tailed)	.247	.445	.296	.697	.791	.447	.798		.916	.427	.722	.525
	N	61	61	61	61	61	61	61	61	61	61	61	61
Using nearby supply chain sources	Pearson Correlation	.063	-.065	.089	.157	.189	.097	.154	-.014	1	.080	.072	-.067
	Sig. (2-tailed)	.630	.619	.494	.228	.144	.455	.237	.916		.542	.581	.609
	N	61	61	61	61	61	61	61	61	61	61	61	61
Use of reverse logistics Practices	Pearson Correlation	.093	-.088	.195	.088	.373**	.194	-.009	.104	.080	1	.093	.186
	Sig. (2-tailed)	.478	.502	.133	.501	.003	.133	.945	.427	.542		.478	.152
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption and Application in Supply Chain	Pearson Correlation	.291*	.037	.181	.080	.211	.107	.230	.046	.072	.093	1	-.066
	Sig. (2-tailed)	.023	.777	.163	.539	.103	.411	.074	.722	.581	.478		.612
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption in Supply Chain of Product Production Process	Pearson Correlation	.072	-.074	.215	.144	.426**	.216	.117	-.083	-.067	.186	-.066	1
	Sig. (2-tailed)	.581	.570	.096	.270	.001	.094	.368	.525	.609	.152	.612	
	N	61	61	61	61	61	61	61	61	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).													
**. Correlation is significant at the 0.01 level (2-tailed).													

Table 5.72 Correlation between Company, Industrial and Regulatory factors and business efficiencies

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.491[a]	.242	.032	.628	.242	1.151	13	47	.344	2.150
a. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies										
b. Dependent Variable: Improved Business Efficiencies										

Table 5.73 Model summary on improved business efficiencies

In this model summary (Table 5.73), the coefficient of correlation (R) is .491 while coefficient of determination (R square) is .242. This means that the organisational practices variables explain about 24.2% of the change in: Improved business efficiencies. That is the independent variables explain 24.2% of variation in the improved business efficiencies. The difference between the R square and adjusted R square means that the model would account 21% (.242 – .032) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .628. This is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.150 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

For this model (Table 5.74 ANOVA), the F-test (1.151), confirms that the model can predict key elements of the supply chain practices using the company, industrial and organisational factors. The significance is .344 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.900	13	.454	1.151	.344[b]
	Residual	18.528	47	.394		
	Total	24.428	60			
a. Dependent Variable: Improved Business Efficiencies						
b. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies						

Table 5.74 Analysis of variance on improved business efficiencies

In Table 5.75, the first coefficient (Constant = -.405) is intercept term. In this case, the intercept is -.405, so when X=0, Y will equal -.405 (regression equations Y = b0 + b1x1).

The B value of -0.405 tell us about the relationship between improved business efficiencies and each predictors.

For the key elements of Innovative supply chain practices factor the β values is positive (.311) we can assume that there is a relationship between the predictor and the outcome. However, the t value is 2.240 and sig. of .030 < .05 means that the predictor is making significant contribution.

For innovative product design practices factor there is a negative coefficient (-0.35) and represents a positive relationship between the predictor. The t value is -0.240 and sig of 0.811 >.05 means that the predictor is not making a significant contribution.

The 'Lean design understanding factor' has positive values (0.66) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 0.430 and with sig. of 0.669 > .05, the predictor is not making a significant contribution.

The Innovative operational efficiencies factor has positive values (0.03) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 0.017 and with sig. of .986 > .05, the predictor is not making a significant contribution.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.405	1.586		-.255	.800
	Total 2.1 - Key elements of Innovative supply chain practices	.329	.147	.311	2.240	.030
	Innovative Product Design Practices	-.029	.121	-.035	-.240	.811
	Lean design understanding	.064	.149	.066	.430	.669
	Innovative operational efficiencies	.003	.155	.003	.017	.986
	Impact of Economic Environment on Product Innovation Process	-.053	.135	-.057	-.393	.696
	Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	.083	.271	.042	.305	.762
	Customer Engagement Practices	-.039	.187	-.032	-.206	.837
	Supply chain commitment from all departments	-.027	.145	-.027	-.185	.854
	Innovative Marketing	-.122	.121	-.134	-1.009	.318
	Use of reverse logistics Practices	.138	.210	.090	.660	.512
	Semi-automated safety quality	.048	.118	.059	.411	.683
	Lean Adoption and Application in	.558	.250	.322	2.228	.031
	Lean Adoption in Supply Chain of Product Production Process	.114	.161	.109	.705	.484
a. Dependent Variable: Improved Business Efficiencies						

Table 5.75 Coefficients – Improved Business Efficiencies

The impact of economic environment on product innovation process factor has negative values (-0.057) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (-0.393) and with sig. of .696 > .05, the predictor is not making a significant contribution.

For 'Impact of organisational processes and management practices on supply chain in your organisation' factor there is a positive coefficient (0.042) and represents a positive relationship between the predictor. The t value is 0.305 and sig of 0.762 > 0 .05 means that the predictor is not making a significant contribution

The customer engagement practices factor has negative values (-0.032) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (-0.206) and with sig. of 0.837 > .05, the predictor is not making significant contribution.

The supply chain commitment from all departments factor has negative values (-0.027) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.185 and with sig. of .854 > .05, the predictor is not making significant contribution.

The innovative marketing factor has negative values (-0.134) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 1.009 and with sig. of .318 > .05, the predictor is making some contribution.

The customer engagement practices factor has positive values (0.066) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (.430) and with sig. of .669 > .05, the predictor is not making a significant contribution.

The use of reverse logistics practices factor has positive values (0.090) and is an indicator of negative relationship between the predictor and outcome. The t factor value is .660 and with sig. of 0.512 > .05, the predictor is not making a significant contribution.

The semi-automated safety quality factor has positive values (0.059) and is an indicator of positive relationship between the predictor and outcome. The t factor value is .411 and with sig. of .683 > .05, the predictor is not making significant contribution.

The lean adoption and application in supply chain factor has positive values (0.322) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 2.228 and with sig. of .031 < .05 is making significant contribution.

The lean adoption in supply chain of product production process factor has positive values (0.109) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 0.705 and with sig. of 0.484 > .05, the predictor is not making a significant contribution.

Improved business efficiencies = -0.405 + 0.311* Key elements of innovative supply chain practices + (-0 .035)* Innovative product design practices + 0.066*Lean design understanding + 0.03*Innovative operational efficiencies + (-0.057)*Impact of economic environment on product innovation process + 0.042*Impact of organisational processes and management practices on supply chain in your organisation + (-0.032)*customer engagement practices + (-0.027)*supply chain commitment from all departments + (-0.134)* Innovative marketing + 0.090*Use of reverse logistics practices + 0.059*Semi-automated safety quality + 0.322*Lean adoption and application in supply chain + 0.109*Lean adoption in supply chain of product production process.

5.13.2 Compliance

Hypothesis 15: Key organisational practices positively influencing improvements in compliance

The following findings from Table 5.76 are worth noting:

- Key elements of innovative supply chain practices are somewhat related to improvements in compliance (.049) and the significance value is .705 >.01.
- Innovative product design practices is poorly related to improvements in compliance (.014) and the significance value is .281 >.01.
- Lean application and adoption in design and product/materials development process practices is somewhat related to improvements in compliance (.262) and the significance value is .041 >.01.
- Innovative products production/operations practices are somewhat related to improvements in compliance (.154) and the significance value is .236 >.01.
- Customer engagement practices is somewhat related to improvements in compliance (.074) and the significance value is .571 >.01.
- Innovative supply chain management practices are somewhat related to improvements in compliance (.16) and the significance value is .219 >.01.

- Innovative marketing practices is somewhat related to improvements in compliance (-.12) and the significance value is 0.343 >.01.
- Using nearby supply chain sources practices are somewhat related to improvements in compliance (.282) and the significance value is .028 >.01;
- Use of reverse logistics practices are somewhat related to improvements in compliance (.093) and the significance value is .477 >.01;
- Lean adoption and application practices are somewhat related to improvements in compliance (.196) and the significance value is .131 >.01.
- Lean adoption in supply chain of product production process practices is somewhat related to improvements in compliance (-.05) and the significance value is 0.73 >.01.

Correlations													
		Improved Compliance	Key elements of Innovative supply chain practices	Innovative Product Design Practices	Lean Application and Adoption in design and product / materials development	Innovative Products Production/Operations Practices	Customer Engagement Practices	Innovative Supply Chain Management Practices	Innovative Marketing Practices	Using nearby supply chain sources	Use of reverse logistics Practices	Lean Adoption and Application in	Lean Adoption in Supply Chain of Product Production Process
Improved Compliance	Pearson Correlation	1	0.049	0.14	.262*	0.154	0.074	0.16	-0.123	.282*	0.093	0.196	-0.045
	Sig. (2-tailed)		0.705	0.281	0.041	0.236	0.571	0.219	0.343	0.028	0.477	0.131	0.73
	N	61	61	61	61	61	61	61	61	61	61	61	61
Key elements of Innovative supply chain practices	Pearson Correlation	0.049	1	-0.137	-0.075	0.036	0.069	0.249	-0.1	-0.065	-0.088	0.037	-0.074
	Sig. (2-tailed)	0.705		0.291	0.566	0.78	0.596	0.053	0.445	0.619	0.502	0.777	0.57
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Product Design Practices	Pearson Correlation	0.14	-0.137	1	0.204	0.198	.274*	0.088	0.136	0.089	0.195	0.181	0.215
	Sig. (2-tailed)	0.281	0.291		0.115	0.127	0.033	0.502	0.296	0.494	0.133	0.163	0.096
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Application and Adoption in design and product / materials development process	Pearson Correlation	.262*	-0.075	0.204	1	0.15	-0.225	0.088	0.051	0.157	0.088	0.08	0.144
	Sig. (2-tailed)	0.041	0.566	0.115		0.249	0.081	0.498	0.697	0.228	0.501	0.539	0.27
	N	61	61	61	61	61	61	61	61	61	61	61	61

Innovative Products Production/Operations Practices	Pearson Correlation	0.154	0.036	0.198	0.15	1	.256*	0.239	0.035	0.189	.373**	0.211	.426**
	Sig. (2-tailed)	0.236	0.78	0.127	0.249		0.047	0.064	0.791	0.144	0.003	0.103	0.001
	N	61	61	61	61	61	61	61	61	61	61	61	61
Customer Engagement Practices	Pearson Correlation	0.074	0.069	.274*	-0.225	.256*	1	0.19	-0.099	0.097	0.194	0.107	0.216
	Sig. (2-tailed)	0.571	0.596	0.033	0.081	0.047		0.143	0.447	0.455	0.133	0.411	0.094
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Supply Chain Management Practices	Pearson Correlation	0.16	0.249	0.088	0.088	0.239	0.19	1	0.034	0.154	-0.009	0.23	0.117
	Sig. (2-tailed)	0.219	0.053	0.502	0.498	0.064	0.143		0.798	0.237	0.945	0.074	0.368
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Marketing Practices	Pearson Correlation	-0.12	-0.1	0.136	0.051	0.035	-0.099	0.034	1	-0.014	0.104	0.046	-0.083
	Sig. (2-tailed)	0.343	0.445	0.296	0.697	0.791	0.447	0.798		0.916	0.427	0.722	0.525
	N	61	61	61	61	61	61	61	61	61	61	61	61
Using nearby supply chain sources	Pearson Correlation	.282*	-0.065	0.089	0.157	0.189	0.097	0.154	-0.014	1	0.08	0.072	-0.067
	Sig. (2-tailed)	0.028	0.619	0.494	0.228	0.144	0.455	0.237	0.916		0.542	0.581	0.609
	N	61	61	61	61	61	61	61	61	61	61	61	61
Use of reverse logistics Practices	Pearson Correlation	0.093	-0.088	0.195	0.088	.373**	0.194	-0.009	0.104	0.08	1	0.093	0.186
	Sig. (2-tailed)	0.477	0.502	0.133	0.501	0.003	0.133	0.945	0.427	0.542		0.478	0.152
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption and Application in	Pearson Correlation	0.196	0.037	0.181	0.08	0.211	0.107	0.23	0.046	0.072	0.093	1	-0.066
	Sig. (2-tailed)	0.131	0.777	0.163	0.539	0.103	0.411	0.074	0.722	0.581	0.478		0.612
	N	61	61	61	61	61	61	61	61	61	61	61	61

Lean Adoption in Supply Chain of Product Production Process	Pearson Correlation	-0.05	-0.074	0.215	0.144	.426**	0.216	0.117	-0.083	-0.067	0.186	-0.066	1
	Sig. (2-tailed)	0.73	0.57	0.096	0.27	0.001	0.094	0.368	0.525	0.609	0.152	0.612	
	N	61	61	61	61	61	61	61	61	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).													
**. Correlation is significant at the 0.01 level (2-tailed).													

Table 5.76 Correlation between Company, Industrial and Regulatory factors and improved compliance

Model Summary[b]										
Model	R	R Sqr	Adjd R Sqr	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Sqr Chnge	F Chnge	df1	df2	Sig. F Chnge	
1	.501[a]	.251	.044	.656	.251	1.211	13	47	.302	2.261
a. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies										
b. Dependent Variable: Improved Compliance										

Table 5.77 Model Summary on improved compliance

In this model summary (Table 5.77), the coefficient of correlation (R) is .501 while coefficient of determination (R square) is .251. This means that the organisational practices variables explain about 25.1% of the change in ‘Improved Compliance’. That is, the independent variables explain 25.1% of variation in the Improved Compliance. The difference between the R square and adjusted R square means that the model would account for 13.2% (.251 - .044) or less variance in the outcome if derived from population rather than a sample. The standard error of estimate for the model is .656; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 2.261 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

For this model (Table 5.78 ANOVA), the F-test (1.211), confirms that the model can predict key elements of the supply chain practices using the ‘Company, Industrial and Organisational’ factors. The significance is .302> .05, so we cannot reject the null hypothesis that the model has no predictive value.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.775	13	.521	1.211	.302[b]
	Residual	20.223	47	.430		
	Total	26.998	60			
a. Dependent Variable: Improved Compliance						
b. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design						

Table 5.78 Analysis of variance on improved compliance

In Table 5.79, The first coefficient (Constant = -0.622) is intercept term. In this case, the intercept is -0.622, so when X=0, Y will equal -.622 (regression equations Y = b0 + b1x1).

The B values tell us about the relationship between improved Compliance and each predictor.

For the Key elements of Innovative supply chain practices factor the standardised coefficient β values is positive (0.137), so we can assume that there is a relationship between the predictor and the outcome. However, the t value is 0.989 and sig. of .327 > .05 means that the predictor is making some contribution.

For ‘Innovative Product Design Practices’ factor there is a positive coefficient (0.078) and represents a positive relationship between the predictor and outcome. The t value is 0.533 and sig of 0.597 < .05 means that the predictor is making a significant contribution.

The ‘Lean design understanding factor’ has positive values (0.179) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.179 and with sig. of 0.244 > .05 is making significant contribution.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.622	1.657		-.376	.709
	Key elements of Innovative supply chain practices	.152	.153	.137	.989	.327
	Innovative Product Design Practices	.067	.126	.078	.533	.597
	Lean design understanding	.184	.156	.179	1.179	.244
	Innovative operational efficiencies	.010	.162	.010	.063	.950
	Impact of Economic Environment on Product Innovation Process	-.127	.142	-.131	-.899	.373
	Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	.258	.283	.123	.912	.366
	Customer Engagement Practices	.051	.195	.040	.262	.795
	Supply chain commitment from all departments	.038	.151	.037	.254	.801
	Innovative Marketing	-.129	.126	-.134	-1.017	.314
	Use of reverse logistics Practices	.315	.219	.195	1.438	.157
	Semi-automated safety quality	.034	.123	.039	.273	.786
	Lean Adoption and Application in	.386	.262	.212	1.474	.147
	Lean Adoption in Supply Chain of Product Production Process	-.102	.168	-.093	-.603	.549
a. Dependent Variable: Improved Compliance						

Table 5.79 Coefficients – Improved Compliance

The Innovative operational efficiencies factor has positive values (0.010) and is an indicator of positive relationship between the predictor and outcome. The t factor value is (0.063) and with sig. of .950 > .05, the predictor is not making significant contribution.

The ‘Impact of Economic Environment on Product Innovation Process factor’ has negative values (-0.131) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (-0.899) and with sig. of .373 > .05 is not making significant contribution.

For ‘Impact of Organisational Processes and Management Practices on Supply Chain in your organisation factor’ there is a positive coefficient (0.123) and represents a positive relationship between the predictor and outcome. The t value is 0.912 and sig of 0.366 > 0 .05 means that the predictor is not making significant contribution.

The ‘Customer Engagement Practices factor’ has negative values (0.040) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.262 and with sig. of 0.795 > .05 is not making significant contribution.

The ‘supply chain commitment from all departments factor’ has negative values (0.037) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.254 and with sig. of .801 > .05 is not making significant contribution.

The innovative marketing factor has negative values (-0.134) and is an indicator of a negative relationship between the predictor and outcome. The t factor value is 1.017 and with sig. of .314 > .05 is making some contribution.

The ‘Use of reverse logistics Practices’ factor has positive values (0.195) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.438 and with sig. of 0.157 > .05, the predictor is making a significant contribution.

The ‘Semi-automated safety quality’ factor has positive values (0.039) and is an indicator of positive relationship between the predictor and outcome. The t factor value is .273 and with sig. of .786 > .05, the predictor is not making a significant contribution.

The ‘Lean Adoption and Application in Supply Chain’ factor has positive values (0.212) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.474 and with sig. of .147 > .05, the predictor is making a significant contribution.

The ‘Lean Adoption in Supply Chain of Product Production Process’ factor has positive values (-0.093) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.603 and with sig. of 0.549 > .05, the predictor is not making a significant contribution.

Improved Compliance = -0.622 + 0.137* Key elements of Innovative supply chain practices + (-0 .078)* Innovative Product Design Practices + 0.179*Lean design understanding + 0.010*Innovative operational efficiencies + (-0.131)*Impact of Economic Environment on Product Innovation Process + (0.123)*Impact of Organisational Processes and Management Practices on Supply Chain in your organisation + (-0.040)*Customer Engagement Practices + (0.037)*Supply chain commitment from all departments + (-0.134)* Innovative Marketing + 0.195*Use of reverse logistics Practices + 0.039*Semi-automated safety quality + + 0.212*Lean Adoption and Application in Supply Chain + (-0.093)*Lean Adoption in Supply Chain of Product Production Process.

5.13.3 Economic Gains

Hypothesis 16: Key organisational practices positively influencing improvements in economic gains

It is clear from Table 5.80 that the key elements of innovative supply chain practices are somewhat related to improvements in economic gains (.129) and the significance value is .322 >.01.

Innovative product design practices are poorly related to improvements in economic gains (.234) and the significance value is .07 >.01.

Lean application and adoption in design and product/materials development process practices are somewhat related to improvements in economic gains (-0.025) and significance value is .847 >.01.

Innovative products production/operations practices are somewhat related to improvements in economic gains ($.349^{**}$) and significance value is 0.006>.01;

Customer engagement practices are somewhat related to improvements in economic gains (0.206) and significance value is 0.111 >.01;

Innovative supply chain management practices are somewhat related to improvements in economic gains (0.182) and significance value is 0.161 >.01;

Innovative marketing practices are somewhat related to improvements in economic gains (0.036) and significance value is 0.785 >.01.

Using nearby supply chain sources practices is somewhat related to improvements in economic gains (.112) and the significance value is 0.392 >.01.

Use of reverse logistics practices is somewhat related to improvements in economic gains ($.390^{**}$) and significance value is 0.002 >.01.

Lean adoption and application practices is somewhat related to improvements in compliance (0.237) and the significance value is 0.066 >.01.

Lean adoption in supply chain of product production process practices are somewhat related to improvements in economic gains (0.23) and significance value is 0.075 >.01.

Correlations													
		Economic Gains	Key elements of Innovative supply chain practices	Innovative Product Design Practices	Lean Application and Adoption in design and product / materials development process	Innovative Products Production/Operations Practices	Customer Engagement Practices	Innovative Supply Chain Management Practices	Innovative Marketing Practices	Using nearby supply chain sources	Use of reverse logistics Practices	Lean Adoption and Application in	Lean Adoption in Supply Chain of Product Production Process
Economic Gains	Pearson Correlation	1	0.129	0.234	-0.025	.349**	0.206	0.182	0.036	0.112	.390**	0.237	0.23
	Sig. (2-tailed)		0.322	0.07	0.847	0.006	0.111	0.161	0.785	0.392	0.002	0.066	0.075
	N	61	61	61	61	61	61	61	61	61	61	61	61
Key elements of Innovative supply chain practices	Pearson Correlation	0.129	1	-0.137	-0.075	0.036	0.069	0.249	-0.1	-0.065	-0.088	0.037	-0.074
	Sig. (2-tailed)	0.322		0.291	0.566	0.78	0.596	0.053	0.445	0.619	0.502	0.777	0.57
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Product Design Practices	Pearson Correlation	0.234	-0.137	1	0.204	0.198	.274*	0.088	0.136	0.089	0.195	0.181	0.215
	Sig. (2-tailed)	0.07	0.291		0.115	0.127	0.033	0.502	0.296	0.494	0.133	0.163	0.096
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Application and Adoption in design and product / materials development process	Pearson Correlation	-0.025	-0.075	0.204	1	0.15	-0.225	0.088	0.051	0.157	0.088	0.08	0.144
	Sig. (2-tailed)	0.847	0.566	0.115		0.249	0.081	0.498	0.697	0.228	0.501	0.539	0.27
	Sum of Squares and Cross-products	-0.652	-1.57	5.924	23.273	3.843	-4.294	2.116	1.336	2.515	2.535	1.119	3.299
	Covariance	-0.011	-0.026	0.099	0.388	0.064	-0.072	0.035	0.022	0.042	0.042	0.019	0.055
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Products Production/Operations	Pearson Correlation	.349**	0.036	0.198	0.15	1	.256*	0.239	0.035	0.189	.373**	0.211	.426**
	Sig. (2-tailed)	0.006	0.78	0.127	0.249		0.047	0.064	0.791	0.144	0.003	0.103	0.001

Practices	N	61	61	61	61	61	61	61	61	61	61	61	61
Customer Engagement Practices	Pearson Correlation	0.206	0.069	.274*	-0.225	.256*	1	0.19	-0.099	0.097	0.194	0.107	0.216
	Sig. (2-tailed)	0.111	0.596	0.033	0.081	0.047		0.143	0.447	0.455	0.133	0.411	0.094
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Supply Chain Management Practices	Pearson Correlation	0.182	0.249	0.088	0.088	0.239	0.19	1	0.034	0.154	-0.009	0.23	0.117
	Sig. (2-tailed)	0.161	0.053	0.502	0.498	0.064	0.143		0.798	0.237	0.945	0.074	0.368
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Marketing Practices	Pearson Correlation	0.036	-0.1	0.136	0.051	0.035	-0.099	0.034	1	-0.014	0.104	0.046	-0.083
	Sig. (2-tailed)	0.785	0.445	0.296	0.697	0.791	0.447	0.798		0.916	0.427	0.722	0.525
	N	61	61	61	61	61	61	61	61	61	61	61	61
Using nearby supply chain sources	Pearson Correlation	0.112	-0.065	0.089	0.157	0.189	0.097	0.154	-0.014	1	0.08	0.072	-0.067
	Sig. (2-tailed)	0.392	0.619	0.494	0.228	0.144	0.455	0.237	0.916		0.542	0.581	0.609
	N	61	61	61	61	61	61	61	61	61	61	61	61
Use of reverse logistics Practices	Pearson Correlation	.390**	-0.088	0.195	0.088	.373**	0.194	-0.009	0.104	0.08	1	0.093	0.186
	Sig. (2-tailed)	0.002	0.502	0.133	0.501	0.003	0.133	0.945	0.427	0.542		0.478	0.152
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption and Application in	Pearson Correlation	0.237	0.037	0.181	0.08	0.211	0.107	0.23	0.046	0.072	0.093	1	-0.066
	Sig. (2-tailed)	0.066	0.777	0.163	0.539	0.103	0.411	0.074	0.722	0.581	0.478		0.612
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption in Supply Chain of Product Production Process	Pearson Correlation	0.23	-0.074	0.215	0.144	.426**	0.216	0.117	-0.083	-0.067	0.186	-0.066	1
	Sig. (2-tailed)	0.075	0.57	0.096	0.27	0.001	0.094	0.368	0.525	0.609	0.152	0.612	
	N	61	61	61	61	61	61	61	61	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).													
*. Correlation is significant at the 0.05 level (2-tailed).													

Table 5.80 Correlation between Company, Industrial and Regulatory factors and economic gain

Model Summary[b]										
Model	R	R Sqr	Adjstd R Sqr	Std. Error of the Estmate	Chnge Statistics					Durbin-Watson
					R Sqr Chnge	F Chnge	df1	df2	Sig. F Chnge	
1	.548[a]	.301	.107	.654	.301	1.554	13	47	.134	1.758
a. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design										
b. Dependent Variable: Economic Gains										

Table 5.81 Model Summary on economic gains

In this model summary (Table 5.81) the coefficient of correlation (R) is .548 while coefficient of determination (R square) is .301. This means that the organisational practices variables explain about 30.1% of the change in 'economic gains'. That is the independent variables explain 30.1% of variation in the economic gains. The difference between the R square and adjusted R square means that the model would account for 19.4% (.301 – .107) or less variance in the outcome, if derived from population rather than a sample. The standard error of estimate for the model is .654. This is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.758 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

For this model (Table 5.82 ANOVA), the F-test (1.554), confirms that the model can predict key elements of the supply chain practices using the 'Company, Industrial and Organisational' factors. The significance is .134 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.637	13	.664	1.554	.134[b]
	Residual	20.096	47	.428		
	Total	28.732	60			
a. Dependent Variable: Economic Gains						
b. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational						

Table 5.82 Analysis of variance on economic gains

In Table 5.83, the first coefficient (Constant = 0.405) is intercept term. In this case, the intercept is -0.405, so when X=0, Y will equal -.405 (regression equations Y = b0 + b1x1).

The B values, 0.405, tell us about the relationship between Economic Gains and each predictor.

For the Key elements of innovative supply chain practices factor the standardised coefficient β values is positive (0.091), so we can assume that there is a relationship between the predictor and the outcome. However, the t value is 0.683 and sig. of .498 > .05 means that the predictor is making some contribution.

For innovative product design practices factor there is a negative coefficient (-0.124) and represents a negative relationship between the predictor. The t value is -0.844 and sig of 0.403 < .05 means that the predictor is making some contribution.

The Lean design understanding factor has positive values (0.176) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.105 and with sig. of 0.275 > .05, the predictor is making some contribution.

The ‘Innovative operational efficiencies’ factor has positive values (0.084) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.596 and with sig. of .554 > .05, the predictor is not making a contribution.

The impact of economic environment on product innovation process factor has negative values (-0.056) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.431 and with sig. of .669 > .05, the predictor is not making significant contribution.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.405	1.652		.245	.807
	Key elements of Innovative supply chain practices	.104	.153	.091	.683	.498
	Innovative Product Design Practices	.120	.126	.135	.956	.344
	Lean design understanding	-.131	.155	-.124	-.844	.403
	Innovative operational efficiencies	.178	.161	.176	1.105	.275
	Impact of Economic Environment on Product Innovation Process	.084	.141	.084	.596	.554
	Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	-.122	.282	-.056	-.431	.669
	Customer Engagement Practices	-.040	.195	-.030	-.203	.840
	Supply chain commitment from all departments	.067	.151	.062	.446	.658
	Innovative Marketing	-.016	.126	-.016	-.127	.899
	Use of reverse logistics Practices	-.004	.218	-.002	-.017	.986
	Semi-automated safety quality	.269	.123	.300	2.196	.033
	Lean Adoption and Application in	.247	.261	.131	.947	.349
	Lean Adoption in Supply Chain of Product Production Process	.112	.168	.100	.669	.507
a. Dependent Variable: Economic Gains						

Table 5.83 Coefficients – Improved economic gains

For ‘impact of organisational processes and management practices on supply chain in your organisation’ factor there is a negative coefficient (-0.056) and represents a negative relationship between the predictor and outcome. The t value is -0.431 and sig of 0.669 > 0 .05 means that the predictor is not making a significant contribution.

The Customer Engagement Practices factor has negative values (-0.030) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (0.203) and with sig. of 0.840 > .05, the predictor is not making a significant contribution.

The ‘supply chain commitment from all departments’ factor has positive values (0.062) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.446 and with sig. of 0.658 > .05 is not making a significant contribution.

The innovative marketing factor has negative values (-0.016) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.017 and with sig. of .986 > .05, at almost 1.0, is not making a contribution.

The use of reverse logistics practices factor has negative values (-0.002) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (-0.017) and with sig. of 0.986 > .05, at almost 1.0, is not making a significant contribution.

The semi-automated safety quality factor has positive values (0.300) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 2.196 and with sig. of .033 < .05, is making a significant contribution.

The lean adoption and application in supply chain factor has positive values (0.131) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.947 and with sig. of 0.349 > .05, is making some contribution.

The lean adoption in supply chain of product production process factor has positive values (0.100) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (0.669) and with sig. of 0.507 > .05, is not making a significant contribution.

Economic Gains = (-0.622) + 0.091* Key elements of Innovative supply chain practices + 0.135* Innovative Product Design Practices + (-0.124)*Lean design understanding + 0.176*Innovative operational efficiencies + 0.084*Impact of Economic Environment on Product Innovation Process + (-0.056)*Impact of Organisational Processes and Management Practices on Supply Chain in your organisation + (-0.030)*Customer Engagement Practices + (0.062)*Supply chain commitment from all departments + (-0.016)* Innovative Marketing + (-0.002)*Use of reverse logistics Practices + 0.300*Semi-automated safety quality + 0.131*Lean Adoption and Application in Supply Chain + (0.100)*Lean Adoption in Supply Chain of Product Production Process.

5.13.4 Cost and Waste Reduction

Hypothesis 17: Key organisational practices influencing positively cost and waste reductions

The following findings from Table 5.84 are worth noting:

- key elements of innovative supply chain practices are very poorly related to improvements cost and waste reductions (0.003). The significance value is 0.979 >.01, almost insignificant at 1.0.
- Innovative product design practices are negatively related to improvements cost and waste reductions (-0.017). The significance value is 0.898 >.01, almost insignificant at nearly 1.0.
- Lean application and adoption in design and product/materials development process practices are somewhat related to improvements cost and waste reductions (.225) and the significance value is .082 >.01.
- Innovative products production/operations practices are somewhat related to improvements cost and waste reductions (.112) and the significance value is 0.39 >.01.
- Customer engagement practices are somewhat related to improvements cost and waste reductions (0.086) and the significance value is 0.509 >.01.
- Innovative supply chain management practices are poorly related to improvements cost and waste reductions (0.242) and the significance value is 0.061 >.01.

- Innovative marketing practices are somewhat negatively related to improvements cost and waste reductions (-0.098) and the significance value is 0.454 >.01.
- Using nearby supply chain sources practices are somewhat related to improvements cost and waste reductions (0.25) and the significance value is 0.052 >.01.
- Use of reverse logistics practices are somewhat related to improvements cost and waste reductions (0.04) and the significance value is 0.762 >.01.
- Lean adoption and application practices are somewhat related to improvements in compliance (0.181) and the significance value is 0.163 >.01.
- Lean adoption in supply chain of product production process practices is negatively related to improvements cost and waste reductions (-0.023) and the significance value is 0.862 >.01.

Correlations														
		Cost and Waste reduction	Key elements of Innovative supply chain practices	Innovative Product Design Practices	Lean Application and Adoption in design and product / materials development process	Innovative Products Production/Operations Practices	Customer Engagement Practices	Innovative Supply Chain Management Practices	Innovative Marketing Practices	Using nearby supply chain sources	Use of reverse logistics Practices	Lean Adoption and Application in	Lean Adoption in Supply Chain of Product Production Process
Cost and Waste reduction	Pearson Correlation	1											
	Sig. (2-tailed)												
	N	61											
Key elements of Innovative supply chain practices	Pearson Correlation	0.003	1										
	Sig. (2-tailed)	0.979											
	N	61	61										
Innovative Product Design Practices	Pearson Correlation	-0.017	-0.137	1									
	Sig. (2-tailed)	0.898	0.291										
	N	61	61	61									
Lean Application and Adoption in design and product / materials development process	Pearson Correlation	0.225	-0.075	0.204	1								
	Sig. (2-tailed)	0.082	0.566	0.115									
	N	61	61	61	61								
Innovative Products Production/Operations Practices	Pearson Correlation	0.112	0.036	0.198	0.15	1							
	Sig. (2-tailed)	0.39	0.78	0.127	0.249								
	N	61	61	61	61	61							
Customer Engagement	Pearson Correlation	0.086	0.069	.274*	-0.225	.256*	1						

Practices	Sig. (2-tailed)	0.509	0.596	0.033	0.081	0.047							
	N	61	61	61	61	61	61						
Innovative Supply Chain Management Practices	Pearson Correlation	0.242	0.249	0.088	0.088	0.239	0.19	1					
	Sig. (2-tailed)	0.061	0.053	0.502	0.498	0.064	0.143						
	N	61	61	61	61	61	61	61					
Innovative Marketing Practices	Pearson Correlation	-0.098	-0.1	0.136	0.051	0.035	-0.099	0.034	1				
	Sig. (2-tailed)	0.454	0.445	0.296	0.697	0.791	0.447	0.798					
	N	61	61	61	61	61	61	61	61				
Using nearby supply chain sources	Pearson Correlation	0.25	-0.065	0.089	0.157	0.189	0.097	0.154	-0.014	1			
	Sig. (2-tailed)	0.052	0.619	0.494	0.228	0.144	0.455	0.237	0.916				
	N	61	61	61	61	61	61	61	61	61			
Use of reverse logistics Practices	Pearson Correlation	0.04	-0.088	0.195	0.088	.373**	0.194	-0.009	0.104	0.08	1		
	Sig. (2-tailed)	0.762	0.502	0.133	0.501	0.003	0.133	0.945	0.427	0.542			
	N	61	61	61	61	61	61	61	61	61	61		
Lean Adoption and Application in	Pearson Correlation	0.181	0.037	0.181	0.08	0.211	0.107	0.23	0.046	0.072	0.093	1	
	Sig. (2-tailed)	0.163	0.777	0.163	0.539	0.103	0.411	0.074	0.722	0.581	0.478		
	N	61	61	61	61	61	61	61	61	61	61	61	
Lean Adoption in Supply Chain of Product Production Process	Pearson Correlation	-0.023	-0.074	0.215	0.144	.426**	0.216	0.117	-0.083	-0.067	0.186	-0.066	1
	Sig. (2-tailed)	0.862	0.57	0.096	0.27	0.001	0.094	0.368	0.525	0.609	0.152	0.612	
	N	61	61	61	61	61	61	61	61	61	61	61	61
*. Correlation is significant at the 0.05 level (2-tailed).													
**. Correlation is significant at the 0.01 level (2-tailed).													

Table 5.84 Correlation between Company, Industrial and Regulatory factors and cost and waste reduction

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.479[a]	.230	.016	.698	.230	1.077	13	47	.401	1.751
a. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies										
b. Dependent Variable: Cost and Waste reduction										

Table 5.85 Model Summary on cost and waste reduction

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.829	13	.525	1.077	.401[b]
	Residual	22.925	47	.488		
	Total	29.754	60			
a. Dependent Variable: Cost and Waste reduction						
b. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies						

Table 5.86 Analysis of variance on cost and waste reduction

In this model summary (Table 5.85), the coefficient of correlation (R) is .479 while coefficient of determination (R square) is .230. This means that the organisational practices variables explain about 23% of the change in ‘cost and waste reduction’. That is the independent variables explain 23% of variation in the cost and waste reduction. The difference between the R square and adjusted R square means that the model would account for 21.4% (.230 – .016) or less variance in the outcome, if derived from population rather than a sample. The standard error of estimate for the model is .698; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.751 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

For this model (Table 5.86 ANOVA), the F-test (1.077), confirms that the model can predict cost and waste reduction efficiencies using the Company, Industrial and Organisational factors. The significance is .401 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.479	1.764		-.272	.787
	Key elements of Innovative supply chain practices	.030	.163	.026	.184	.854
	Innovative Product Design Practices	-.109	.134	-.121	-.813	.420
	Lean design understanding	.192	.166	.178	1.158	.253
	Innovative operational efficiencies	-.042	.172	-.041	-.245	.808
	Impact of Economic Environment on Product Innovation Process	-.105	.151	-.102	-.695	.491
	Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	.394	.302	.179	1.308	.197
	Customer Engagement Practices	.094	.208	.070	.454	.652
	Supply chain commitment from all departments	.184	.161	.167	1.142	.259
	Innovative Marketing	-.084	.135	-.084	-.625	.535
	Use of reverse logistics Practices	.312	.233	.184	1.337	.188
	Semi-automated safety quality	.007	.131	.008	.053	.958
	Lean Adoption and Application in	.374	.279	.196	1.344	.185
	Lean Adoption in Supply Chain of Product Production Process	-.043	.179	-.037	-.239	.812
a. Dependent Variable: Cost and Waste reduction						

Table 5.87 Coefficients – Cost and Waste reduction

In Table 5.87, the first coefficient (Constant = -0.479) is intercept term. In this case, the intercept is -0.479, so when X=0, Y will equal -0.479 (regression equations Y = b0 + b1x1).

The B values (-0.479), tell us about the relationship between improved compliance and each predictor.

For the key elements of innovative supply chain practices factor the standardised coefficient β values is positive (0.026) we can assume that there is a relationship between the predictor and the outcome. However, the t value is (0.184) and sig. of 0.854 > .05, almost 1.0, means that the predictor is not making a contribution.

For Innovative product design practices factor there is a negative coefficient (-0.121) and represents the negative relationship between the predictor. The t value is -0.813 and sig of 0.420 < .05 means that the predictor is making a significant contribution.

The lean design understanding factor has positive values (0.178) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.158 and with sig. of 0.253 > .05, the predictor is making some contribution.

The Innovative operational efficiencies factor has negative values (-0.041) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.256 and with sig. of .808 > .05, with almost 1.0, is not making a significant contribution.

The impact of economic environment on product innovation process factor has negative values (-0.102) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (-0.695) and with sig. of 0.491 > .05, is not making a significant contribution.

For 'impact of organisational processes and management practices on supply chain in your organisation factor' there is a positive coefficient (0.123) and represents a positive relationship between the predictor and outcome. The t value is 0.912 and sig of 0.366 > 0.05 means that the predictor is not making a significant contribution.

The ‘Customer Engagement Practices’ factor has positive values (0.179) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.308 and with sig. of 0.197 > .05, is making some contribution.

The supply chain commitment from all departments factor has positive values (0.167) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.142 and with sig. of 0.259 > .05 is making some contribution.

The innovative marketing factor has negative values (-0.084) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.625 and with sig. of 0.535 > .05 is making some contribution.

The use of reverse logistics practices factor has positive values (0.184) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.337 and with sig. of 0.188 > .05, is making some contribution.

The semi-automated safety quality factor has positive values (0.008) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.053 and with sig. of 0.958 > .05, at almost 1.0, is not making much contribution.

The lean adoption and application in supply chain factor has positive values 0.196 and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.344 and with sig. of .186 > .05, is making some contribution.

The ‘Lean Adoption in Supply Chain of Product Production Process’ factor has negative values (-0.037) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.239 and with sig. of 0.812 > .05, at almost 1.0, is not making a significant contribution.

Cost and Waste reduction = (-0.479) + 0.026* Key elements of Innovative supply chain practices + (-0 .121)* Innovative Product Design Practices + 0.178*Lean design understanding + (-0.041)*Innovative operational efficiencies + (-0.102)*Impact of Economic Environment on Product Innovation Process + 0.179*Impact of Organisational Processes and Management Practices on Supply Chain in your organisation + 0.070*Customer Engagement Practices + 0.167*Supply chain commitment from all departments + (-0.084)* Innovative Marketing + 0.184*Use of

reverse logistics Practices + 0.008*Semi-automated safety quality + + 0.196*Lean Adoption and Application in Supply Chain + (-0.037)*Lean Adoption in Supply Chain of Product Production Process

5.13.5 Sustainability and Environmental image

Hypothesis 18: Key organisational practices influencing improvements sustainability and Environmental image

The following findings from Table 5.88 are worth noting:

- Key elements of innovative supply chain practices are positively related to improvements sustainability and environmental image (0.129) and the significance value is 0.322 >.01.
- Innovative product design practices are poorly related to related to improvements sustainability and environmental image (0.234) and the significance value is .07 >.01.
- Lean application and adoption in design and product / materials development process practices are negatively related to improvements sustainability and environmental image (-0.025) and the significance value is 0.847 >.01. It is almost insignificant at nearly 1.0.
- Innovative products production/operations practices are positively related to improvements sustainability and environmental image (0.349) and the significance value is .006 <.01.
- Customer engagement practices are positively related to improvements sustainability and Environmental image (0.206) and the significance value is .111 >.01.
- Innovative supply chain management practices are poorly related to improvements sustainability and environmental image (.182) and the significance value is 0.161>.01.
- Innovative marketing practices are somewhat related to improvements sustainability and environmental image (0.036) and the significance value is 0.785 >.01.

- Using nearby supply chain sources practices are somewhat related to improvements sustainability and environmental image (0.112) and the significance value is 0.392>.01.
- Use of reverse logistics practices are positively related to improvements sustainability and environmental image (0.390^{**}) and the significance value is 0.002 <.01.
- Lean adoption and application practices are somewhat related to improvements in compliance (0.237) and the significance value is 0.066 >.01.
- Lean adoption in supply chain of product production process practices are somewhat related to improvements sustainability and environmental image (0.23) and the significance value is 0.075 >.01.

Correlations													
		Economic Gains	Key elements of Innovative supply chain practices	Innovative Product Design Practices	Lean Application and Adoption in design and product / materials development process	Innovative Products Production/Operations Practices	Customer Engagement Practices	Innovative Supply Chain Management Practices	Innovative Marketing Practices	Using nearby supply chain sources	Use of reverse logistics Practices	Lean adoption and application in supply chain	Lean Adoption in Supply Chain of Product Production Process
Economic Gains	Pearson Correlation	1	0.129	0.234	-0.025	.349**	0.206	0.182	0.036	0.112	.390**	0.237	0.23
	Sig. (2-tailed)		0.322	0.07	0.847	0.006	0.111	0.161	0.785	0.392	0.002	0.066	0.075
	N	61	61	61	61	61	61	61	61	61	61	61	61
Key elements of Innovative supply chain practices	Pearson Correlation	0.129	1	-0.137	-0.075	0.036	0.069	0.249	-0.1	-0.065	-0.088	0.037	-0.074
	Sig. (2-tailed)	0.322		0.291	0.566	0.78	0.596	0.053	0.445	0.619	0.502	0.777	0.57
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Product Design Practices	Pearson Correlation	0.234	-0.137	1	0.204	0.198	.274*	0.088	0.136	0.089	0.195	0.181	0.215
	Sig. (2-tailed)	0.07	0.291		0.115	0.127	0.033	0.502	0.296	0.494	0.133	0.163	0.096
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Application and Adoption in design and product / materials development process	Pearson Correlation	-0.025	-0.075	0.204	1	0.15	-0.225	0.088	0.051	0.157	0.088	0.08	0.144
	Sig. (2-tailed)	0.847	0.566	0.115		0.249	0.081	0.498	0.697	0.228	0.501	0.539	0.27
	Sum of Squares and Cross-products	-0.652	-1.57	5.924	23.273	3.843	-4.294	2.116	1.336	2.515	2.535	1.119	3.299
	Covariance	-0.011	-0.026	0.099	0.388	0.064	-0.072	0.035	0.022	0.042	0.042	0.019	0.055
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Products Production/Operations Practices	Pearson Correlation	.349**	0.036	0.198	0.15	1	.256*	0.239	0.035	0.189	.373**	0.211	.426**
	Sig. (2-tailed)	0.006	0.78	0.127	0.249		0.047	0.064	0.791	0.144	0.003	0.103	0.001
	N	61	61	61	61	61	61	61	61	61	61	61	61

Customer Engagement Practices	Pearson Correlation	0.206	0.069	.274*	-0.225	.256*	1	0.19	-0.099	0.097	0.194	0.107	0.216
	Sig. (2-tailed)	0.111	0.596	0.033	0.081	0.047		0.143	0.447	0.455	0.133	0.411	0.094
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Supply Chain Management Practices	Pearson Correlation	0.182	0.249	0.088	0.088	0.239	0.19	1	0.034	0.154	-0.009	0.23	0.117
	Sig. (2-tailed)	0.161	0.053	0.502	0.498	0.064	0.143		0.798	0.237	0.945	0.074	0.368
	N	61	61	61	61	61	61	61	61	61	61	61	61
Innovative Marketing Practices	Pearson Correlation	0.036	-0.1	0.136	0.051	0.035	-0.099	0.034	1	-0.014	0.104	0.046	-0.083
	Sig. (2-tailed)	0.785	0.445	0.296	0.697	0.791	0.447	0.798		0.916	0.427	0.722	0.525
	N	61	61	61	61	61	61	61	61	61	61	61	61
Using nearby supply chain sources	Pearson Correlation	0.112	-0.065	0.089	0.157	0.189	0.097	0.154	-0.014	1	0.08	0.072	-0.067
	Sig. (2-tailed)	0.392	0.619	0.494	0.228	0.144	0.455	0.237	0.916		0.542	0.581	0.609
	N	61	61	61	61	61	61	61	61	61	61	61	61
Use of reverse logistics Practices	Pearson Correlation	.390**	-0.088	0.195	0.088	.373**	0.194	-0.009	0.104	0.08	1	0.093	0.186
	Sig. (2-tailed)	0.002	0.502	0.133	0.501	0.003	0.133	0.945	0.427	0.542		0.478	0.152
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption and Application in	Pearson Correlation	0.237	0.037	0.181	0.08	0.211	0.107	0.23	0.046	0.072	0.093	1	-0.066
	Sig. (2-tailed)	0.066	0.777	0.163	0.539	0.103	0.411	0.074	0.722	0.581	0.478		0.612
	N	61	61	61	61	61	61	61	61	61	61	61	61
Lean Adoption in Supply Chain of Product Production Process	Pearson Correlation	0.23	-0.074	0.215	0.144	.426**	0.216	0.117	-0.083	-0.067	0.186	-0.066	1
	Sig. (2-tailed)	0.075	0.57	0.096	0.27	0.001	0.094	0.368	0.525	0.609	0.152	0.612	
	N	61	61	61	61	61	61	61	61	61	61	61	61
**. Correlation is significant at the 0.01 level (2-tailed).													
*. Correlation is significant at the 0.05 level (2-tailed).													

Table 5.88 Correlation between Company, Industrial and Regulatory factors and improved sustainability and environmental image

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.391[a]	.153	-.082	.681	.153	.651	13	47	.798	1.866
a. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies										
b. Dependent Variable: Improved sustainability and environmental Image										

Table 5.89 Model Summary on improved sustainability and environmental image

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.932	13	.302	.651	.798[b]
	Residual	21.822	47	.464		
	Total	25.754	60			
a. Dependent Variable: Improved sustainability and environmental Image						
b. Predictors: (Constant), Lean Adoption in Supply Chain of Product Production Process, Use of reverse logistics Practices, Lean Adoption and Application in , Innovative Marketing, Impact of Organisational Processes and Management Practices on Supply Chain in your organisation, Total 2.1 - Key elements of Innovative supply chain practices, Customer Engagement Practices, Semi-automated safety quality , Impact of Economic Environment on Product Innovation Process, Innovative Product Design Practices, Supply chain commitment from all departments, Lean design understanding, Innovative operational efficiencies						

Table 5.90 Analysis of variance on improved sustainability and environmental Image

In this model summary (Table 5.89), the coefficient of correlation (R) is .391, while coefficient of determination (R square) is .153. This means that the company, industrial and organisational variables explain about 15.3% of the change in 'Improved sustainability and environmental Image'. That is the independent variables explain 15.3% of variation in the innovative operational efficiencies. The difference between the R square and adjusted R square means that the model would account for 6.6% [.153 – (-.082] or less variance in the outcome, if derived from

population rather than a sample. The standard error of estimate for the model is .681; this is the standard deviation of actual values of dependant variable about the regression line of estimated dependant variable values. The value of the Durbin Watson statistics is 1.866 which is not too far off 2.0 and indicates that the assumption of independent error has been met.

For this model (Table 5.90 ANOVA), the F-test (.651), confirms to us that the model can predict key elements of the supply chain practices using the 'Company, Industrial and Organisational' factors. The significance is .798 > .05, so we cannot reject the null hypothesis that the model has no predictive value.

In Table 5.91, the first coefficient (Constant = 0.743) is intercept term. In this case, the intercept is -0.743, so when X=0, Y will equal 0.743 (regression equations Y = b0 + b1x1).

The B values (0.743), tell us about the relationship between improved sustainability and environmental image and each predictor.

For the key elements of innovative supply chain practices factor the standardised coefficient β values is positive (0.053), so we can assume that there is a positive relationship between the predictor and the outcome. The t value is 0.360 and sig. of 0.720 > .05, means that the predictor is not making a contribution.

For Innovative product design practices factor there is a negative coefficient (-0.073) and represents the negative relationship between the predictor. The t value is -0.471 and sig of 0.640 > .05 means that the predictor is making a significant contribution.

The lean design understanding factor has negative values (-0.170) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.107 and with sig. of 0.915 > .05, makes hardly any contribution.

The Innovative operational efficiencies factor has positive values (0.036) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.203 and with sig. of .840 > .05, with almost 1.0, is not making a significant contribution.

The impact of economic environment on product innovation process factor has positive values (0.021) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 0.134 and with sig. of 0.894 > .05 is not making a significant contribution.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.743	1.721		.432	.668
	Key elements of Innovative supply chain practices	.057	.159	.053	.360	.720
	Innovative Product Design Practices	-.062	.131	-.073	-.471	.640
	Lean design understanding	-.017	.162	-.017	-.107	.915
	Innovative operational efficiencies	.034	.168	.036	.203	.840
	Impact of Economic Environment on Product Innovation Process	.020	.147	.021	.134	.894
	Impact of Organisational Processes and Management Practices on Supply Chain in your organisation	.288	.294	.141	.977	.334
	Customer Engagement Practices	.278	.203	.222	1.370	.177
	Supply chain commitment from all departments	-.016	.157	-.015	-.099	.921
	Innovative Marketing	-.020	.131	-.022	-.155	.878
	Use of reverse logistics Practices	.027	.227	.017	.117	.907
	Semi-automated safety quality	.159	.128	.188	1.248	.218
	Lean adoption and application in supply chain	-.090	.272	-.051	-.332	.742
	Lean Adoption in Supply Chain of Product Production Process	.058	.175	.055	.333	.740
a. Dependent Variable: Improved sustainability and environmental Image						

Table 5.91 Coefficients – Improved sustainability and environmental image

For ‘impact of organisational processes and management practices on supply chain in your organisation’ factor there is a positive coefficient (0.141) and represents a positive relationship between the predictor and outcome. The t value is 0.977 and sig of 0.334 > 0.05 means that the predictor is not making a significant contribution.

The customer engagement practices factor has positive values (0.222) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.370 and with sig. of 0.177 > .05, is making some contribution.

The supply chain commitment from all departments factor has positive values (-0.015) and is an indicator of negative relationship between the predictor and outcome. The t factor value is (-0.099) and with sig. of 0.921 > .05, is making some contribution.

The innovative marketing factor has negative values (-0.022) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.155 and with sig. of 0.878 > .05 is making some contribution.

The use of reverse logistics practices factor has negative values (-0.017) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 0.177 and with sig. of 0.907 > .05, is making some contribution.

The semi-automated safety quality factor has positive values (0.188) and is an indicator of positive relationship between the predictor and outcome. The t factor value is 1.248 and with sig. of 0.218 > .05, is making some contribution.

The lean adoption and application in supply chain factor has negative values (-0.051) and is an indicator of negative relationship between the predictor and outcome. The t factor value is -0.332 and with sig. of 0.742 > .05, is making some contribution.

The lean adoption in supply chain of product production process factor has positive values (0.055) and is an indicator of negative relationship between the predictor and outcome. The t factor value is 0.333 and with sig. of 0.740 > .05, is not making a significant contribution.

Improved sustainability and environmental Image = 0.743 + 0.053* Key elements of Innovative supply chain practices + (-0 .073)* Innovative Product Design Practices + (-0.17)*Lean design understanding + 0.036*Innovative operational efficiencies + (-0.021)*Impact of Economic Environment on Product Innovation Process + 0.141*Impact of Organisational Processes and Management Practices on Supply Chain in your organisation + 0.222*Customer Engagement Practices + (-0.015)*Supply chain commitment from all departments + (-0.022)* Innovative Marketing + 0.017*Use of reverse logistics Practices + 0.188*Semi-automated safety quality + (-0.051)*Lean Adoption and Application in Supply Chain + (0.055)*Lean Adoption in Supply Chain of Product Production Process.

5.15 Summary

This chapter completes the research data testing and analyses for the study and explains the development and applications of measures used to analyse the data.

The responses from the survey were grouped according to Likert scale and analysed using Statistical Package for the Social Sciences (SPSS, version 22.0). A comprehensive analysis was undertaken to test the robustness of the approach and validity of the survey results.

The analysis identified three overarching themes influencing the supply chain innovation – Company, Industry and Regulatory. A number of hypotheses were designed and subsequently used to measure impact of the key themes on the industry practices. The organisational practices were in turn used to determine the impact on the organisational performance.

A number of hypotheses were developed and tested particularly for two sets of relationships:

- Between the key themes of company, industry and regulatory variables and their impacts on the key practices; And
- Key practices of the organisations and the organisational performances.

The results were presented in two groups. The first group examined the relationship between the themes – company, industry and regulatory – with key practices; and second the impact of practices on the performances of the organisation (Table 5.92).

The hypotheses test results - impact of industrial, regulatory and company themes on the key processes of the organisations; impact of organisational practices and their impacts on the organisational performances are presented in the Table 5.10 below.

	Hypothesis	NULL HYPOTHESIS
H1	H1: the company, industrial and regulatory factors positively affect Key elements of Innovative supply chain practice	Accept
H2	H2: the company, industrial and regulatory factors positively affect innovative product design practices	Reject
H3	H3: the company, industrial and regulatory factors positively affect lean application and adoption in design and product / materials development process	Accept
H4	H4: the company, industrial and regulatory factors positively affect innovative production/operational efficiencies	Reject
H5	H5: the company, industrial and regulatory factors positively influence through economic environment on product innovation process	Accept
H6	H6: the company, industrial and regulatory factors positively influence Impact of organisational processes and management practices on supply chain	Accept
H7	H7: the company, industrial and regulatory factors positively impact customer engagement practices	Accept
H8	H8: the company, industrial and regulatory factors positively impact supply chain management practices	Accept
H9	H9: the company, industrial and regulatory factors positively influence innovative Marketing	Reject
H10	Hypothesis 10: the company, industrial and regulatory factors positively affect use of reverse logistics practice	Accept
H11	H11: the company, industrial and regulatory factors positively affect semi-automated equipment adoption	Accept
H12	H12: the company, industrial and regulatory factors positively affect lean adoption and application in supply chain	Reject
H13	H13: the company, industrial and regulatory factors positively affect lean adoption and application in supply chain of product production process	Reject
H14	Hypothesis 14: Key organisational practices positively influencing improvements in business efficiencies	Accept
H15	Hypothesis 15: Key organisational practices positively influencing improvements in compliance	Accept
H16	Hypothesis 16: Key organisational practices positively influencing improvements in economic gains	Accept
H17	Hypothesis 17: Key organisational practices influencing positively cost and waste reductions	Accept
H18	Hypothesis 18: Key organisational practices influencing improvements sustainability and environmental image	Accept

Table 5.92 Summary of the Hypotheses outcomes

Chapter Six

Industry Case Study

6.1. Introduction

The company selected for the case study is a leading supplier of concrete and cement solutions to the UK construction industry. However, since the company wishes to remain anonymous and not compromise its market position, it will therefore be referred to as 'Lesta'.

For this case study, site visits and in-depth interviews with project managers, technical manager, supply chain/purchase managers and senior management were conducted to gain in depth views of the projects and practices covering different management levels and points of views on a range of topics as follows:

- The underlying supply chain challenges to be addressed in light of the themes identified in the research;
- The supply chain innovation ideas and new approaches for the supply chain;
- The projects impact on the organisations performance;
- The barriers to implementing the supply chain innovations;
- The solutions to overcome these supply chain barriers.

For this case study, Figure 6.1 and Figure 6.2 were used as the main driving factors and conversational guides. In order to inform the criteria for the conversations with the different managers within Lesta, the theoretical themes from the literature review (Figure 6.1); questions used for the data collections; and the subsequent data analysis (in chapter 5) were used.

Lesta provides extensive product range and therefore solutions for all types of applications; from standard products that require a uniform, quick and easy application up to more complex and specific tailor-made solutions.

With continuous update of product design and high level of technological advancement, Lesta continues to enjoy recognition for quality and competitiveness that they deserve.

Lesta recognises that all components of the supply chain need to function coherently and collaboratively to deliver the projects on time and within the budgets and this provides added benefits of improving the productivity.

The supply chain performance also affects the lifecycle performance of the products supplied. The organisation and reusability are also considered to be a key consideration for the products

The Lesta managers stressed that one of the key measures for the company (this also applies to industry), when considering sustainability is carbon reduction as well as waste reduction. These two (carbon reduction and waste management) are important considerations and the supply chain links are critical in delivering on these two. Another key consideration is the affordability through high-quality with inexpensive infrastructure and that too is influenced by the supply chain performance.

The UK as a geographical location is not a disaster prone part of the world and therefore, does not suffer hardships such as major earth quakes. However, the flooding resulting from extra rainfalls due to climate change is a major phenomenon. Therefore, through the innovative practices in the UK construction industry supply chain activities there is an opportunity to develop resilience.

Lesta pointed out that within the UK, the buildings already in use, contributes to health and well-being of occupants and there needs to be continuous innovation through use of innovative materials and processes during the construction phase and this too is influenced by the supply chain. Lesta firmly believes that the supply chain innovation and all associated innovations make important contribution to the business challenges.

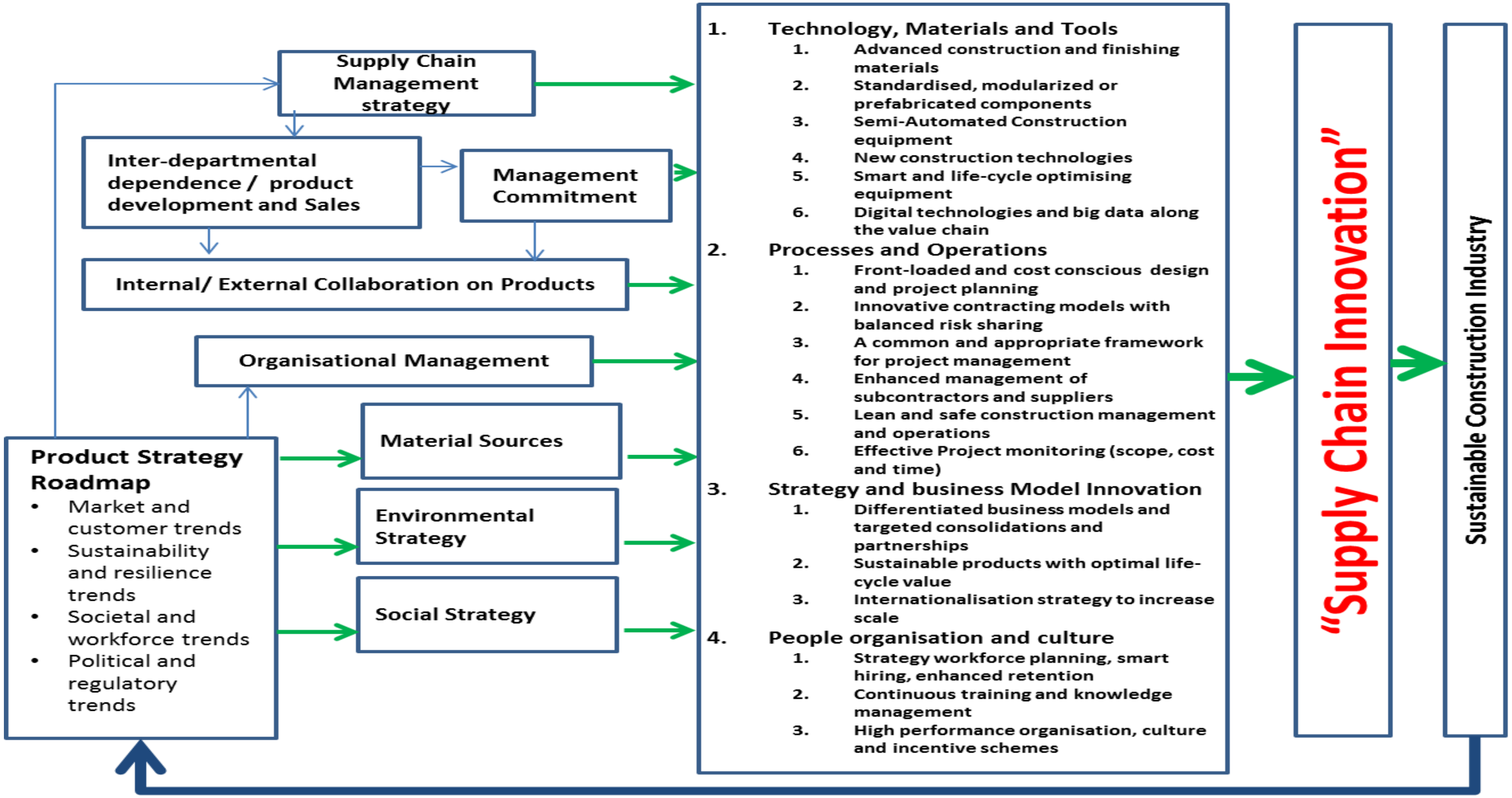

Figure 6.1 Emerging areas of research study for the UK construction industry sustainability

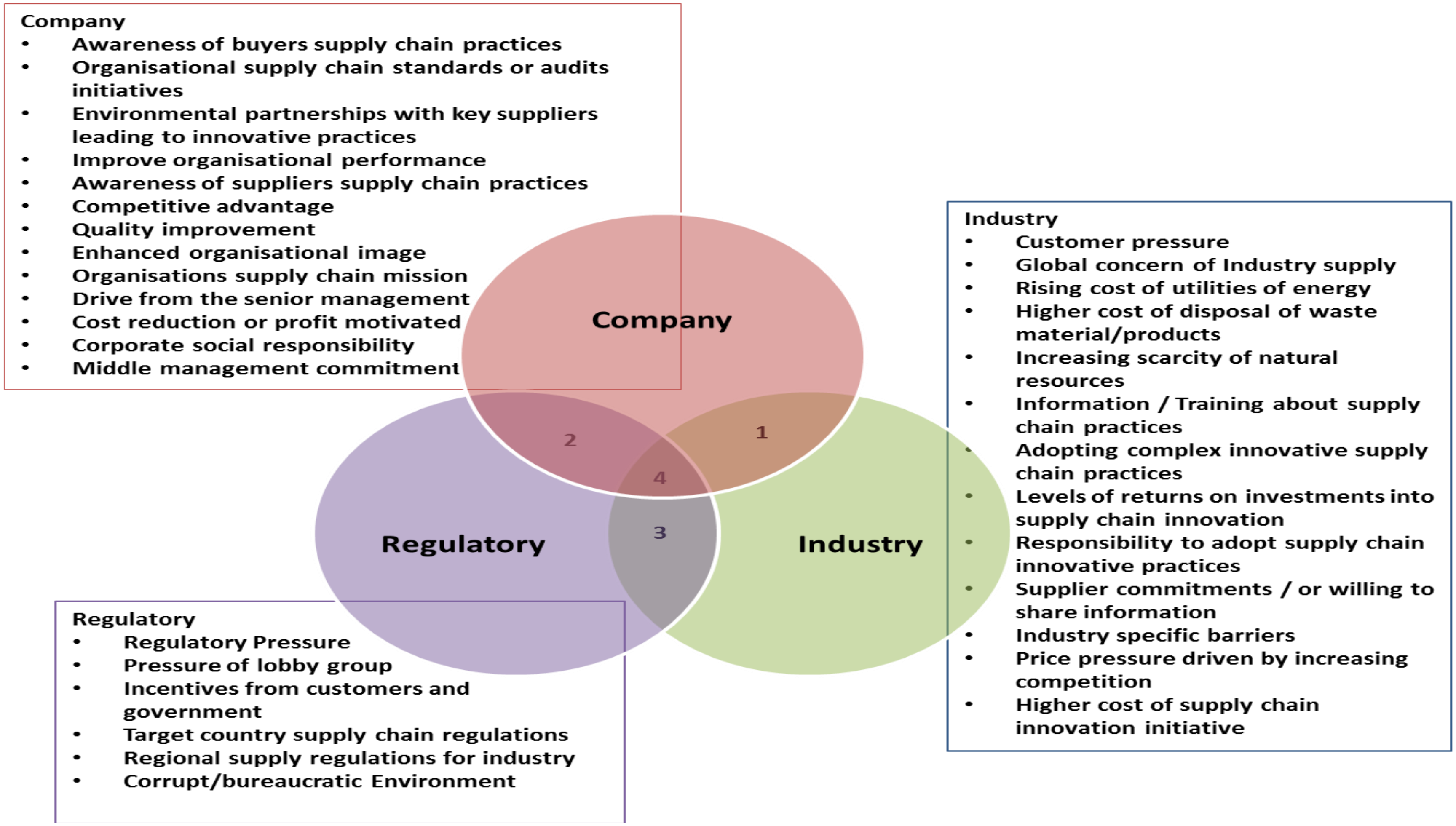

Figure 6.2 Towards the development of a conceptual framework

6.2. Company Factors

Lesta management believes that while there are global trends within the construction industry impacting the UK construction industry and its supply chain; the suppliers within the construction industry supply chain are in a position to take on some of the measures contributing towards sustainability of the UK construction industry.

There is also a recognition that some of the work around sustainability can be done by the companies on their own. Some would require collaboration with other suppliers in the value chain; and there is a sincere belief amongst the Lesta management that some of the work can be done by the regulatory authorities and the UK construction industry.

Lesta believes that there is a huge opportunity for the business through the application of new digital technologies, adoption of innovative materials and acquiring tools for new ways of working and business processes. The net benefit for Lesta will be in the form of improved productivity and on time deliveries. That is, for the final end user, newly constructed building will be of superior quality, safer and constructed with optimised working conditions and will adopt total respect for environment.

Lesta emphasises that continued supply chain innovation is necessary to attracting, developing and retaining the best professionals in the UK construction industry. Traditionally, the UK construction industry is not known for attracting the best talent. The importance of attracting the best workforce is further complicated by the ageing workforce.

Lesta recognises that there is a scarcity in the UK construction industry skills due to ageing workforce and changing demographics patterns. The fast-changing technologies and associated sophistication adds to the challenges of acquiring new and broader skills sets, crucial for the UK construction industry. The nature of workforce arrangements and the relevant difficulties as a result of tendering process and industry projects delivery methods require co-working between different contracting partners.

6.2.1. Improve Organisational Performance

Lesta recognises that the ability to deliver innovative products within building products manufacturing, provides an important leverage; and that product innovation can mainly come from new or improved construction industry materials. This presents a significant challenge as well as opportunity since in many projects the products and materials are almost third of the total project cost.

Lesta is always prepared to invest in supply chain innovation initiatives because there is a firm belief within the company that incremental innovation of existing materials as well as step change innovative initiatives involving new materials; and the benefits are expected to be recognised through new features, benefits and applications.

For Lesta, products and solutions range and its roadmap of products development includes three elements:

- Innovative improvements for supply chain products solutions with the existing materials with existing features, benefits and applications.
- Developing supply chain products range with multi-functional performances from new innovative materials.
- Developing entirely new materials/product ranges with innovative features, benefits and applications.

Lesta believes that it is critically important to build important competencies in-house and create a knowledge base of evidence on features and applications of its products. Subsequently, it is important to transfer that knowledge to the projects teams of suppliers as well as customers in the supply chain.

Lesta believes that by engaging more proactively, quickly as well as decisively in the supply chain of the UK construction industry, it will benefit from higher number of larger contracts and reduce its risks exposure.

6.2.2. Competitive Advantage

Lesta noted that not only the UK but the global construction industry supply chain is moving rapidly with innovation products and practices. For the UK construction industry supply chain partners, more and more growth opportunities in the UK as well as international markets, new financing mechanisms, and fast changing customer demands are motivating the industry's players to innovate and expand, both geographically and in terms of product/service solutions offerings. It is notable how the UK construction industry high performers are diversifying more than most other supply chain partners, developing more efficient processes and adopting customer-focused operational processes or initiatives in order to gain larger market share.

Lesta postulates that to compete, the UK construction industry supply chain partner organisations will need to maintain new approaches to risk management and capital allocation, operational efficiency and supply chain management. Additionally, they will need to develop novel ways of attracting, retaining and deploying a mobile and multilingual workforce with relevant skills. As the UK construction industry continues to evolve from Business to Business (B-2-B) to Business to Business to Customers (B-2-B-2-C) these strengths will become even more critical differentiators for the UK construction industry high performers of tomorrow.

The Lesta managers pointed out that the UK construction industry is dependent on the competitive procurement processes. Furthermore, the UK construction industry supply chain has historically maintained a cautious approach to adopting new materials, innovative product design and solutions delivery. This cautious practice leads to inward focused project management practices rather than collaborative and expansive thinking and therefore, Lesta believe this also continues to fuel the fragmentation in the industry and therefore in the supply chain practices.

Lesta recognises that the UK construction industry remains receptive and open to overseas companies since this in some projects leads to economies of scale as well as scope and specialisation for the supply chain participants and provide much needed skills access.

For the UK construction industry supply chain contracts, there is a belief, that current UK tendering practices restricts foreign companies' market and tend to favour their domestic industry when awarding contracts. However, according to Lesta management, for sustainability to prevail in the UK construction industry, less bias and more competitive tendering process will lead to more benefits through the adoption of innovation in the industry supply chain.

6.2.3. Quality Improvement

For nearly the entire population of the world, the built environment heavily influences quality of life. In the United States, for instance, people on average spend nearly 90% of their time indoors (Klepeis et al, 2001).

It is recognised at Lesta that the building and the materials in the supply chain used for the construction and finishing process have a significant impact on the health and well-being of its end users or occupants. This may include aesthetics – design and colours, indoor air quality comfort and safety. The quality of building and its construction is critical since the users of these buildings spend significant amount of time indoor.

For Lesta the real value is in improving the quality of construction products and the quality of materials used in the supply chain which contributes to a healthy indoor environment, improved sustainability and reduced costs. Therefore, undertakings towards sustainability, quality and cost reduction are always considered to be beneficial by all Lesta members.

According to Lesta for the UK construction industry there needs to be an additional concern for health quality and safety both for the industry workers and the people who subsequently occupy the buildings. The quality of workers health and productivity are linked to the quality of the indoor environment. This required quality level is influenced by the choices made during project development and construction of the building. For the UK construction sector's supply chain participant's responsibility does not end with the delivery of the building at the end of the project. The whole process is influenced by the initial selection of materials in the supply chain. In short, the safer the materials used in the construction industry supply chain, the better the quality health and the environment.

6.2.4. Enhanced Organisational Image

Lesta recognises that it needs to adopt best practices for all its participants in the UK construction supply chain as well as construction sites. It is of crucial importance that the communities and the environment recognise Lesta as one promoting culture of safety. The managers further stress that; it is of critical importance that the concerns relating to the public, workers and the environment are addressed by the UK construction industry supply chain.

The Lesta managers made reference to 'The Considerate Constructors Scheme' – a non-profit organization founded by the UK construction industry to improve its image. This scheme addresses concerns relating to the general public, the workforce and the environment. It has established a code of considerate practice to guide the behaviour of its members. The scheme is open to construction companies of all types and size, including large main contractors undertaking short duration work, specialist contractors, those who work in the UK construction Industry supply chain, domestic contractors and individual tradesmen.

Lesta as one of the key products supplier as well as a supply chain player in the UK construction industry is reviewing its relationships with suppliers to reduce the organisational costs, improve quality and reduce lead time for increasingly complex and innovative supply chain products.

Some of the UK construction industry supply chain players, such as Lesta, have comprehensive international sourcing operations and use e-procurement. On the other hand, some of the UK construction industry supply chain practitioners have in-house initiatives to ensure sub-contractor compliance. According to Lesta, the effective construction industry supply chain innovators have also shortened lead times by developing turnkey solutions and pre-fabricated products, embracing a more customer-oriented approach and not slow to adopt practices from industries.

Since some of these UK construction industry supply chain participants are not reluctant to invest in data analysis capabilities, they can measure and monitor the unpredictability of raw material prices, as well as price variations among suppliers. This is further backed up by operational excellence programmes which ensure that projects within the UK construction industry supply chain are delivered on time and within the budget.

6.2.5. Environmental Partnerships with key Suppliers Leading to Innovative Practices

Lesta recognises that by working with the UK construction industry supply chain partners, there are many opportunities to innovate. For a start, Lesta points out that, it is always good to seek to adapt a supply chain solution to suit the local market requirements. Also, it is important to create a prototype of innovative supply chain products so that the stakeholders can gain understanding of look and feel of the solution being offered and what is achievable with the aid of the technology. However, it must also be stressed that the best solutions do not always have to be high-tech.

In the UK construction industry supply chain, any innovative approach to construction practices or projects are likely to provoke scepticism. By creating prototypes that industry actors can see and feel, offers one important way of creating and ensuring acceptance.

Lesta emphasises the importance of collaborating closely with suppliers to develop, test and implement innovations within the UK construction industry supply chain. The innovations in the concrete-mix design and pumping, and the prefabricated products are developed by suppliers seeking innovation within the industry. These practices require close collaboration between contractors and suppliers to test and implement the innovations in the UK's construction industry supply chain and challenging construction environment.

For Lesta when working on new contracts, the knowledge of the different partners is sought even in the planning phase to enable preventative alterations and prevent costly modifications later in the projects delivery.

In practical terms for Lesta, forming supply chain partnerships with key industry players through its partnerships with established UK construction industry leaders, it has succeeded in overpowering the market resistance and refining its technology solutions to resolve critical construction supply chain challenges through new materials or innovative products.

Lesta believes that the reputation of these construction industry supply chain partners has boosted its own reputation and trustworthiness and raised its profile in the UK construction industry as one of the recognised market leader in delivering innovative solution. As a result of the innovative supply chain partnership approach, Lesta is considered to be a supply chain innovator rather than simply performing as an external industrial influence in the supply chain.

This innovative supply chain approach warrants that Lesta shares in the risk of its solutions and possesses a common agenda to yield positive outcomes for both suppliers as well as customers.

6.2.6. Organisations Supply Chain Mission

Lesta wishes to build a wider eco-system and therefore, has particularly earmarked its supply chain. That is, the organisation recognises that to make the innovative products or materials solutions, it needs to adopt the work approaches that break the status quo which typically require different supplies, skills and processes. Additionally, the Lesta management believes that for its UK target market, developing a competent construction industry local supply chain is key to implementing innovation effectively, whether it is for a low-skill and high-tech or low-tech solution and high-skill requirements.

For Lesta, the mission is about - meeting customer requirements through the best value sourcing of materials and/or products and services while maintaining the environmental, social and ethical requirements in the sustainable supply chain process.

Lesta managers stress that through its mission, the business should be recognised as essential and efficient business practice in providing innovative sustainable products for the UK construction industry. This makes it essential for all company functions to work as a well-coordinated team. This mission based approach provides Lesta to make informed and balanced decisions whether it concerns creating order for the business;

processing the order and sourcing materials or products and services in the supply chain; and delivering the product to customers for all its projects.

6.2.7. Drive from the Senior Management

The Lesta leadership firmly believes that they have a responsibility to its UK operations as well as customers and to the UK construction industry supply chain transformation. Lesta emphasises that it is of crucial importance that it increases cross-company collaboration in the supply value chain by sharing best practices, developing the larger supply chain, setting industry standards, conducting joint industry marketing and coordinating their engagement with the public sector; and therefore indirectly contributing to the sustainability of the UK construction industry.

For Lesta, the essence of market focus and position is in targeting the right business at the right moment in the right market segment. Lesta senior management continues to enhance its competitiveness by strategizing and adapting and therefore securing strategic positions in high-growth emerging markets and taking advantage of domestic infrastructure opportunities while securing lucrative contracts overseas.

By working proactively with emphasis on innovative products as well as processes with the supply chain partners Lesta has also diversified its materials/products and services portfolio both upstream and downstream. Lesta is transforming from pure construction materials and products supplier to business value adding areas such as project management contractors and concession companies, managing and maintaining facilities beyond delivery completion.

The Lesta management recognises that to remain high performer in the UK construction industry supply chain it needs to strike the right balance between competing opportunities. That is, develop an ability to get in and out fast to minimize risk and without damaging the tactical and strategic partnerships which are continuously being developed. In the UK, for some supply chain products Lesta have made calculated shifts into high-margin products segments of the construction industry using innovative materials.

The Lesta senior management believe in nurturing valuable customer relationships over a long time. Moreover, by figuring out a specific role dedicated to customer relationship management within the company Lesta, management are staying strategically close to key customers.

6.2.8. Cost Reduction or Profit Motivated

Lesta management points out that as the UK construction industry continues to digitize, with the use of aerial drones, Building Information Modelling (BIM), wireless sensing, 3D scanning and other relevant technologies for the construction industry, it wishes to be in position to capitalize on the supply chain benefits. The so-called Internet of Things (IoT) is expected to generate additional revenues for supply chain applications known as predictive maintenance and operations management of the contracts. This means there is continuous monitoring of current practices and learning to implement new technology led solutions.

This is especially relevant for Lesta since some of its business contracts are low-margin businesses and therefore, keen to improve their profitability. Lesta believes that profits can be improved by optimizing planning, design, engineering, construction and operation and maintenance (O&M) as well as identifying new revenue streams through the better use of data or implementing technology solutions.

One of the challenges for Lesta is that the legacy IT systems used in the UK construction industry supply chain are holding back latest technology adoptions, creating barriers to capitalizing on digital transformation with speed, and this results in lower profit margins.

6.2.9. Corporate Social Responsibility

The Lesta management believes that, as a provider of infrastructure and building assets, the UK construction industry is at the heart of the economy and directly affects the quality of life for millions in this country. However, there is a mixed reception to the thought that exit from Europe and other trends will further strengthen the industry’s sustainability as well as social importance. In the UK new migrants across the border and rural-urban migration continues to present the need for affordable housing and social infrastructure. Lesta believes there will be additional business growth opportunities as a result of these changes affecting the UK construction industry. This leads to construction industry becoming a subject of discussion amongst the UK population and most public debates. Lesta acknowledged the recent motivations to build and upgrade infrastructure in an affordable way in the UK; and argues that the construction industry has to step up by improving its supply chain productivity, environmental performance and social impact.

There is a buzz amongst managers when they talk about the new technologies such as building information modelling (BIM), 3D printing, wireless sensing and autonomous equipment. The managers talk enthusiastically about how these offer the potential to transform the construction industry supply chain and improve its corporate social responsibility image.

However, the adoption of new technologies in the UK construction industry remains low due to uncertainty about the value proposition of these new technologies. Furthermore, there is a lack of clarity on how to implement solution in organizations' strategy. Consequently, there is a low commitment to corporate social responsibility agenda amongst the UK construction industry supply chain participants and Lesta manager are aware of this.

Lesta considers maintenance of sustainability of industry as a main positive driving contributor on the UK construction industry supply chain – incorporating the delivery of projects and life of assets. That is, Lesta views the UK construction industry as the assembly of materials, the concept of circularity in reducing waste, reusing and recycling for a closed-loop economy.

6.2.10. Middle Management Commitment

Lesta middle management believes that the UK construction industry has vast potential. It believes that its middle management has a crucial role to improve productivity and efficiency, particularly as a result of digitalization, innovative technologies and new construction techniques. Additionally, there is hunger for new knowledge amongst middle managers, as they acknowledge the need to rise up to the challenge of catching up with the rapid emergence of augmented reality, drones, 3D scanning and printing, Building Information Modelling (BIM), autonomous equipment and advanced building materials. Lesta expects that the middle management will play a crucial role in adopting and exploiting the UK construction industry supply chain innovations. Therefore, the Lesta operations in the UK construction industry will continue to boost productivity, streamline their project management and procedures, and enhance quality and safety.

To capture all potential business opportunities offered to the UK construction industry, Lesta supply chain operations require a committed and concerted effort by the middle managers across many aspects, from technology, operations and strategy to personnel and regulation.

Lesta management stressed that use of common and appropriate frameworks/programmes for the UK construction industry supply chain provides competitive advantage for middle management when managing projects. It is common knowledge in the UK construction industry as far as Lesta are concerned that, the completion of construction projects regularly relies heavily on the expertise or even intuition of the individual project manager working at middle management level. While no two construction projects are likely to be identical, the learning from any one project proves beneficial when applied to another. The managers from Lesta, emphasise that there is an opportunity for the UK construction industry supply chain companies to institutionalize the lessons so that middle management contribution continuous to improve across different projects.

The Lesta management stress that its own middle managers in the UK construction industry can add to the continuous improvements of project management framework by collecting and consolidating project-management data; standardize the identification of best practices, and making sure that the best-practice standards actually get applied at the project level.

Lesta predicts that educating middle managers responsible for project management and other important decision-making in the supply chain processes as well as the management best practices may need to become mandatory; and this will improve significantly the supply chain performance.

6.2.11. Awareness of Buyers Supply Chain Practices

Lesta pointed out that it is one thing for its supply chain players to generate great ideas but another thing to implement them. In this regard, a very helpful approach being considered is to create innovation accelerators, which involves customers in the supply chain to drive innovation.

While the aim is to take a customer-centric approach to devising innovations in the supply chain, seeing from not just customers owning assets but also from end-users perspective.

Lesta points out that the UK construction industry building products supply chain is highly fragmented in which project developers, investors, architects, designers and contractors are normally on one side and the end-users and external stakeholders on the other. The side which includes the developers is also often fragmented.

According to Lesta successful supply chain innovators must choose a customer-centric approach to innovations. That is, take user expectations and challenges for design and engineering. With the advancement of the technologies the end-user bias must be maintained during all project phases; and the constant aim must be to enhance the user experience.

The Lesta managers point out that the end-user-centric approach can also be realised in a 'building app' on supply chain participants smartphone or tablet, enabling one-stop personalized control of temperature and lighting levels, room bookings, parking reservations, and so on.

Lesta points out that it had faced some resistance to its automated design solutions, but in time architecture and design firms came to accept the solution when the materials and products team showed them how it simplified the traditional tiresome and tedious proposal process. Lesta works with the construction industry supply chain partners and creates close-fitting solutions and always keen to develop new data-driven revenue streams for its customers.

6.2.12. Awareness of Suppliers Supply Chain Practices

According to Lesta due to cyclical nature of the UK construction industry supply chain, from time to time purchasing construction materials and products presents some serious challenges. Although some of these challenges are of temporary nature. The resulting project delays force the UK construction industry supply chain partners to either order additional materials in advance or purchase and store in anticipation of more orders.

Therefore, Lesta points out that it is critically important to integrate the UK construction industry supply chain suppliers and subcontractors more effectively.

The aim for the UK construction industry supply chain should be to establish a nimble as well as responsive supply chain able to respond flexibly and swiftly to changes in the external environment (such as regulatory, social and economic etc.) and integrate with internal function of the business.

The first step for a supply chain contractor might be to consolidate some of its internal functions such as procurement, quality and logistics into a central team, to work more closely with the supply chain (Bains and Company, 2015). The contractor would then abandon the old system – multiple, ever-changing transactional supply contracts, with great complexity and little reliability for both sides. Finally, to switch to a new system involving fewer contracts but more strategic long-term cooperation.

Lesta adds that such a switch not only will reduce the contractor's administrative burden and initial set-up costs, but will enable construction industry suppliers to conduct long-term planning and will often bring innovations to the market. Nevertheless, the long-term commitment should be accompanied by a transparent, fair and regularly revised evaluation of the suppliers.

6.2.13. Organisational Supply Chain Standards or Audits Initiatives

Lesta has a supplier code which clearly states that it reserves the right to monitor and audit each supplier’s compliance with its supplier code. Therefore, the suppliers must cooperate by providing relevant information that it requests at regular intervals and by making individuals accessible so Lesta could conduct a meaningful audit.

Similarly, supply partners are required to evaluate their respective supply chain to ensure compliance with Lesta supplier code and to conduct audits of its supply chain when requested by Lesta. Any non-compliance by partners or its supply chain must be effectively remedied both in a timely manner and at no additional cost to Lesta or its customers.

It is very clearly stated that breaches of the supplier code may negatively impact partners’ business relationship with Lesta.

The supplier code covers the topics such as health, safety and well-being, fair working conditions, no discrimination or harassment, environment, protection of assets, property, and equipment, confidentiality, protection of personal data (data protection), anti-corruption and anti-bribery, fair competition, conflict of interest, hospitality and gifts.

6.3. Industry Factors

The importance of the UK construction industries crucial role in societal, environmental and economic domains is recognised by Lesta management and it firmly believes that even small improvement in performance could result in considerable business gains.

The uniqueness of the UK construction industry characteristics is outlined by the Lesta management as follows:

- When working on a typical UK construction project there are usually different stake holders with differing needs or interests as well as requirements.

- The supply chain participants tend to operate from project to project and practice on site construction processes.
- The supply chain is highly fragmented in the UK construction Industry.
- The UK construction industry has low profitability and lacks major capital investments initiatives.
- The UK construction industry is very cyclical and there is high volatility in different parts of the UK.
- The workforce within the UK construction industry is ageing, there is lack of skills and there is instability in accessing right skills at right time.
- Due to lack of skills and competitive tendering process there is immaturity in defining projects and articulating technical assessments in the UK construction industry supply chain.
- For the UK construction industry the disputes resolution within the supply chain is very time consuming, expensive and complex.
- Within the UK construction industry there is over reliance on lowest price bidding.
- In some contracts for the UK construction industry there is often insufficient budgets or payments are made in incremental phase which limits the innovation in the supply chain or proactive participation for suppliers.
- The UK construction industry supply chain struggles to supply innovative products with new materials due to cautious approach on part of the UK customers.
- Within the UK construction industry different levels of risk burden is passed on to the supply chain participants in the value chain.

Lesta recognises that there is opportunity to apply technologies, develop innovative supply chain products and processes. This in turn will lead to new construction techniques and productivity for the UK construction industry. To this end the company is willing to play its part in the UK construction industry supply chain to accept the new opportunities more dynamically and change the way it has usually operated.

6.3.1. Customer pressure

In many of the recent projects the customer as well as cost pressures has forced Lesta to collaborate with the suppliers in the supply chain. Lesta has recognised that the technologies suppliers have an extremely important role to play when developing innovative products using new materials. This has forced the management to look at different business models in order to deliver innovative products or products solutions to the market and therefore, overcome industry resistance.

For Lesta, management believes that it is critically important to continue to work in partnerships with the industry technology suppliers in order to integrate the product innovations and its functionalities into the buildings without increasing cost burdens and reducing the risks associated with the new technologies.

6.3.2. Global Concern of Industry supply

Lesta managers recognise that there are many challenges and concerns for the UK construction industry and differing partners' collaboration. However, the main concern is within its supply chain and there is a strong belief that better collaboration is needed along the supply value chain. That is, better collaboration between partners with similar expertise as well as new to the industry companies bringing either an innovative product or process.

Lesta points out somewhat frustratingly, the current practice in the UK construction industry of passing on the risk in the supply chain, since it has large impact on the level of innovation practiced or adopted in the UK construction industry supply chain.

Lesta believes that there is an opportunity for the industry to promote collaboration within the industry as well as cross-industry between the companies. These initiatives could include joint research and data sharing or analysing initiatives. It is believed that these initiatives could aid knowledge sharing in the UK construction industry supply chain and promote common understanding in terms of design, construction and operations.

Furthermore, it is believed that this approach could facilitate independent standards certification and sustainability assurances while adopting innovative practices in terms of new products or new processes or new markets or combinations of these.

6.3.3. Rising Cost of Utilities of Energy

According to the United Nations Environment Programme (2007), energy use, buildings are responsible for 25-40% of the global total, thereby contributing hugely to the release of carbon dioxide.

Therefore, Lesta acknowledges that the real value for its business is in aiding or helping to improve the construction processes and innovative materials resulting in improved product quality in building projects. This subsequently, leads to a healthy environment for building users, improved industry sustainability and overall reduced lifetime costs.

Lesta maintains that a deliberate effort towards this improving well-being of end users, cost reduction and sustainability of the industry through supply chain innovation could lead to good will as well as profits for the UK construction industry supply chain participants.

6.3.4. Higher Cost of Disposal of Waste Material/Products

Lesta pointed out that over time the UK construction industry has remained fundamentally unchanged; in that vertical projects require workers to add layers of building materials, either wood, bricks, or concrete, one on top of the other.

However, the Lesta managers' point out that in the contemporary construction industry practices the historical approach is ill-suited to the modern age in three key respects since it limits productivity, construction is heavily reliant on the skills of individual and traditional construction methods produce large amounts of waste, noise and dust, in defiance of required modern environmental standards.

Lesta has made a point of continuously enhancing its materials for the UK construction industry supply chain. When it had reached the limit of what is possible with traditional materials and technologies, it adapted into large-scale 3D printing; a move aimed at further improving its production processes, increasing its design options and reducing wastes.

Lesta's management is confident that its technologies adoption is far more environment-friendly than conventional reinforced concrete. For some of the supply chain partners of Lesta there is minimized waste in the actual construction process and modular dry construction method is dust-free. In some cases the waste management initiatives of Lesta saves 30-60% of material relative to traditional construction. So, the adoption of technologies has a specific appeal for the UK construction industry supply chain, which has higher labour costs and expected environmental standards requirements are stringent.

6.3.5. Increasing Scarcity of Natural Resources

Due to cyclical nature of the UK construction industry supply chain, purchasing materials and components presents a serious concern. It could be shortage of some materials such as cement, although these tend to be temporary.

Lesta managers point out with concern that when a project is delayed due to lack of supplies, it has a knock on effect on the whole project. Alternatively, some building product suppliers tend to build up large stocks of some materials in an effort to compensate for an unreliable supply chain and this could tie up large amount of working capital.

Lesta believes it is of critical importance to integrate suppliers and subcontractors more effectively, and that task falls mainly to the main contractor. Different measures are available to the UK construction industry supply chain and not just in the planning phase but throughout the entire project. For some of the industry suppliers, goal should be to establish a responsive supply chain able to respond flexibly and promptly to changes in the external market environment.

The construction projects hold ups include weather-related hold-ups, changes in scope and schedule or regulatory change.

Lesta emphasises that the UK construction industry supply chain should be regarded as a model of partnerships.

That is, the first step for the UK construction industry supply chain contractor might be to consolidate some of its internal functions - procurement, quality and logistics, into a central team, enabling closer work with the construction industry supply chain. This will enable the contractor to abandon the old system – multiple, ever-changing transactional supply contracts, with great complexity and little reliability for both sides – and enables switching to a new system involving fewer contracts and more strategic long-term partners' cooperation in the supply chain. Lesta managers stress that this switch could reduce the contractor's administrative burden and initial set-up costs; enable suppliers to conduct long-term planning. This would aid in bringing innovations to the market within the UK construction industry supply chain.

Lesta points out that the long-term UK construction industry supply chain commitment should be accompanied by a transparent, fair and regularly revised evaluation of the suppliers within the UK construction industry supply chain.

6.3.6. Information / Training about Supply Chain Practices

For Lesta, the lack of qualified task or projects managers and ageing workforce create multiples problems. Ideally, the company wishes to adopt the development of supply chain innovation for construction and digital skills through tailored job-training initiatives. The management point out that the recent incentive from the UK government for apprentice scheme is helping to address the company needs. However, there is opportunity to do more for the UK construction industry supply chain and possibly develop a grants programmes which could be used for a variety of UK construction industry supply chain needs - product development, BIM, design for manufacturing and assembly or lean construction

Likewise, there are opportunities for educating the suppliers and sub-contractors within the UK construction industry supply chain on the benefits of adopting new materials, new products, BIM, and provide training courses to supply chain partners to use it more beneficially. For Lesta, some of the projects in the supply chain have shown how powerful a tool BIM is, especially since it is used by sub-contractors and suppliers in the UK construction industry supply chain.

Lesta wishes to see more being done at industry level and even from regulatory perspective to promote the benefits of the BIM model, discussing the UK construction industry's supply chain participants concerns openly and helping the companies with relevant financing and training if necessary.

Additionally, there is an opportunity to provide training and information to the UK construction industry supply chain participants such as designers and architects to overcome their resistance. The specifics of this could include raising awareness and increase acceptance of its disruptive technology, Lesta is willing to partner with design institutes to engage and work with designers and architects – key agents in promoting the innovative materials and innovative technology led solutions.

However, Lesta stresses that the UK construction industry supply chain partners need to work collectively and cooperatively to promote the short term and long term benefits as well as successes. This could also serve to overcome the resistance from construction workers.

6.3.7. Adopting Complex Innovative Supply Chain Practices

Lesta stresses that many advanced building materials with cutting edge innovation do not achieve deserved acceptance due to higher initial investment costs required and since the net benefits are spread over the lifetime of the project. The additional reasons include the lack of track record of success for the new material or even lack of sufficient understanding amongst the UK construction industry supply chain decision makers or lack of information needed for making complex trade-offs on price vs quality, durability and ecological benefits.

There is also another concern amongst the engineers, contractors and suppliers when thinking of recommending innovative building materials. – The liability risk and the UK construction industry supply chain need to take steps to address this fear.

6.3.8. Levels of Returns on Investments into Supply Chain Innovation

Lesta believes that the return on the investments into the innovations in the UK construction industry supply chain is dependent on the construction projects creating certainty to deliver on time and on budget and also, improving the productivity of the construction sector. This in turn depends on an ability to improve materials or product performance while reducing the lifecycle costs of construction assets and designs accommodating recycling; the improved sustainability of the products through reduced carbon emission and waste during construction projects; the creation of high-quality, affordable building in the UK; designing, building and delivering assets which improve the well-being of end users; and ensuring that UK building infrastructure is resilient against climate change and natural elements such as extra rainfalls or flooding.

Lesta points out that there are also some UK construction industry issues which needs addressing and include some reluctance from SMEs within the UK construction industry supply chain to implement innovative practices. Additional points worth considering include; most of the UK construction sector supply chain training is geared towards sustaining existing or familiar material; most of the training is designed around existing material and not much around innovative materials; amongst the building products manufacturing SMEs there is a lack of resources to proactively encourage innovation. The UK construction industry supply chain suffers from poor advocacy/support group's activities; the innovative materials or products manufacturers do not market the products sufficiently or proactively; the customers and manufacturers do not have strategic relationship unless they are large organisations and engage with each other on regular basis. The industry trends are not recognised sufficiently fast enough; the supply chain partners – both suppliers and subcontractors – are adopting usual specification and old practice of working alone where it concerns developing innovative products, or markets or processes; some of the UK construction industry supply chain practitioners consider the additional design requirements as annoying and stay away from being active promoters of the supply chain innovation.

6.3.9. Responsibility to Adopt Supply Chain Innovative Practices

Lesta recognises its responsibility to the UK construction industry supply chain practices. Additionally, it continues to address issues around the technical knowledge/training gaps. It is aware of the potentially negative perceptions held by the industry professionals in the UK construction industry supply chain. First, when innovative materials are introduced in the construction supply chain there is always questions raised about the resilience or lack of track records as well as standards and that needs managing; often the new materials for the construction products are not readily available and that needs managing too. Secondly, the SME suppliers or contractors are reluctant to adopt new innovative products since the risks of failure are considered to be higher and that could lead to costly endeavour The introduction of new materials may require new guidelines for designs and tools; in some cases the customers might be misinformed about the potentials of the new materials and that needs addressing. Thirdly, the lack of skilled workers combined with ageing workforce leads to added complexities in managing innovative materials and products. Fourthly, some of the UK construction industry supply chain participants consider the adoption of innovative materials in the supply chain as too expensive and prohibitively costly; then there is the added complication of warranting and insuring the new solutions. Fifthly, due to the fragmented nature of the supply chain industry there is no coherent approach to create case studies. Other issues include; some of the middle managers consider the supply chain innovations as not rewarding and hold poor perceptions about the new materials applications. For example, in some cases the product designers consider adoption of new materials as simply too lengthy.

6.3.10. Supplier Commitments / or Willing to Share Information

Lesta considers the creation of talented, multidisciplinary teams and maintain a responsive or agile organisation to develop innovative products and solutions. This also presents an opportunity to challenge the commonly understood belief that innovations are only produced by lone intellects who work in isolation to produce industry transforming ideas for materials or products.

Therefore, according to Lesta success could come as a result of creation of multidisciplinary, multifunctional and multitalented teams to overcome barriers which moves from functional thinking to cross-functional thinking.

Lesta, pointed to some projects where multidisciplinary approach had served its supply chain innovation drive:

- In one project, it overcame design and engineering challenge through a team consisting of individuals with unique combination of diverse skills.
- In another project the core team included representatives from the project's developer, designer, contractor and end user customer, bringing varied talents together in a highly creative way, supported by shared enthusiasm for innovation and commitment to an open-discussion as well as culture of sharing.

Lesta further stresses that in some projects it is critical to share knowledge between teams, departments and countries in order to leverage global expertise.

6.3.11. Industry Specific Barriers

According to Lesta there are many challenges and barriers which impact the innovative supply chain practices in the UK construction industry supply chain.

There is a lack of knowledge, understanding and skills when looking at the UK construction industry supply chain practices and for adopting innovative materials or designing new products. The benchmarked data from innovative and successful construction industry supply chain practices are often not available. The specifications for the innovative materials with its features, benefits and application, are often not considered in developing marketing strategy. This leads to organisation missing an opportunity to enhance the reputation of the product. In some UK construction industry supply chain organisation, there is no one responsible for considering supply chain innovation. The UK construction industry supply chain culture for building products is not proactively promoting the supply chain innovation. For some of the suppliers in the UK construction industry the materials or products values are fairly low and therefore not able to lead in the supply chain innovation initiatives. There is also some negative information in the market about some of the construction materials in the industry. The UK construction industry lacks the availability of cost effective and different facilities which can demonstrate projects and product testing to support SMEs.

6.3.12. Price Pressure Driven by Increasing Competition

Lesta believes there is a definite price pressure with increasing competition and decreasing profit margins. However, Lesta believe that there is a need for considering innovative contracting models with balanced risk sharing in the UK construction industry supply chain.

In order to understand the full potential of innovative solutions and cost-conscious design and project planning, it is crucial to involve all supply chain suppliers and subcontractors. However, it must also be noted that the innovative solutions offered by partners for both short and longer term UK construction industry benefits must maintain full legal compliance, ensuring equal treatment of all bidders, for instance, and operating a vigorous system of checks and balances. All those parties involved in the construction supply chain process owners, contractors, subcontractors and suppliers clearly have a vested interest in delivering projects on time and subsequently getting paid on-time. Lesta projects that this in some ways could serve to facilitate a shift away from the sequential design-bid-build approach to a more integrative approach.

In fact, Lesta stresses that the construction companies could take on additional roles by applying innovative contracting models. For example, in a design and build process a single supply chain participant in the UK construction industry supply could have a single contract to provide all designs and project construction.

Lesta sees benefits of early contractor involvement model could integrate design development and construction planning by including a contractor in the early planning stages. Lesta believes that in the first phase, the contractor advises on project engineering and planning and a target price could be agreed; and if that target price is met, the contractor would be recruited for the construction phase as well.

Lesta pointed to an example, where a contractor had helped to find a cost-effective design alternative and developed together with the other supply chain partners, an innovative solution with an overall reduced cost.

There is an opportunity for companies which could develop and apply smart collaboration initiatives. However, it is to be noted that any new, collaborative initiative increases the risk of conflict between the UK construction industry supply chain partners as new methods are tried out.

6.3.13. Higher Cost of Supply Chain Innovation Initiative

Lesta stressed that there is a perception that all innovative efforts in the UK construction industry supply chain are costly. However, Lesta pointed out that while evaluating the cost of Building Information Modeling (BIM), there were numerous benefits, some diverse and some obvious, and often hard to quantify precisely. In fact, it can be claimed that costs and benefits could be distributed with supply chain partners and costs decrease with the number of users.

However, it is important to note some specifics when considering the UK construction industry supply chain. First, for some innovative materials and products there is a high cost. Some of the innovations within the construction industry supply chain are priced in isolation without considering lifecycle costs in decision making. Secondly, some solutions are not promoted or even given attention by the regulatory authorities. Thirdly, some solutions require additional training for the supply chain professionals in order to adopt it in the UK construction industry practices. Fourthly, due to financial sector squeeze the UK supply chain partners are reluctant to invest in innovative solutions to promote new materials or new processes. Consequently, businesses tend to maintain preferences for existing and known materials and products or solutions.

Fifthly, the new products resulting from innovative materials require improved or enhanced specifications. Also, due to lack of wider application or some unique features it is not easy to compare with existing cost models.

Notably, some customers are simply not ready to take risk where it concerns innovative construction materials or products. Furthermore, project financing for some of the innovative materials solutions is considered to be mismatch and time consuming because of the fragmented nature of the UK construction industry supply chain and focus on project to project costings. Finally, it is noted that, for some of the suppliers there is economies of scale issues due to the business size and therefore limited when it comes to competing with industry players with larger financial muscle. Therefore, there is reluctance to adopt the supply chain innovations which includes new materials since there is a fear of increasing the supply lead times.

6.4. Regulatory

Lesta recognises that it has a role to play in contributing towards driving the UK construction industry supply chain transformation. However, it emphasises that without regulatory support all supply chain partners in the UK construction industry may struggle. Lesta states with firmness that the necessary long term strategic planning, forward thinking project ownership and adoption of innovative supply chain practices can only come about through support of the policy makers.

A key recommendation was the need for an effective public-private partnership for removing the implementation barriers and successfully addressing the UK construction industry supply chain challenges, while delivering the project which also addresses sustainability.

6.4.1. Regulatory pressure

In order to deal with regulatory pressures Lesta continues to monitor political, economic, social, technological environmental and legal (PESTEL) situation in the UK as well as globally. In the main, it diligently studies the underlying social trends and the political landscape in order to carry out scenario planning.

Where the regulations are taking shape within the construction industry, Lesta considers different outcomes from scenario planning; and articulates a realistic vision of regulations from the UK construction industry sustainability points of view.

Where an advocacy strategy is being developed for the UK construction industry supply chain, Lesta aims to contribute in developing advocacy strategy towards the chosen supply chain or sustainability scenario; including an identification of partners, possibly pursuing a multi-stakeholder approach.

6.4.2. Pressure of Lobby Group

Lesta puts forward a number of innovative thoughts. First, the resistance shown by the UK construction industry and the cynicism demonstrated by local communities can be countered by building demonstration/prototype units. Secondly, supply shortages and design challenges can be resolved by enhancing local supply chains and integrating available building technology from the early stage of the project. Thirdly, in the UK construction industry supply chain there is scepticism on the part of developers and customers towards the new building technology. Furthermore, there is resistance from the traditional building and masonry industry, which is interested in protecting its vested interests by lobbying local, regional and national government. The demonstration and prototype units help to articulate the advantages of its technologies and influence end user customers. Finally, once the innovations in the supply chain and its final products are accepted, Lesta seeks to work together with local people as distributors.

Lesta warns that overcoming resistance from developers could lead to changes in the business model together with increasing maturity of the industry.

6.4.3. Incentives from Customers and Government

Lesta emphasized that for the UK construction industry supply chain it is crucial to introduce more responsive as well as flexible procurement and contracting models that align incentives; improve risk-sharing; and enable earlier and longer-term collaboration between building owners, contractors and operators.

Lesta pointed to one of its construction project where the project involved different supply-chain models from different sectors and some key elements were identified as characterizing these models. That is, the critical success factors for the project were alignment, incentives, collaboration, integrated teams, visible programmes and minimizing of waste.

In the UK construction industry supply chain an effective governance of major contracts procurement can be achieved by having clear organisational structures and operating models for planning and execution. Furthermore, assigning task force to drive high-priority projects; applying lean principles to procurement; and equipping purchasing teams with appropriate skills.

Lesta promotes idea of making the construction projects more attractive for the supply chain participants by ensuring visibility of the forward pipeline to help suppliers respond to market opportunities and ensure a stable project pipeline over time. Also, providing a clearly defined bidding model and information-rich tenders; offering SMEs training on public procurement procedures; and providing dedicated, continuous access to funding.

6.4.4. Target Market Supply Chain Regulations

Lesta point out that for some of the target markets for its materials and products, there are different challenges relating to regulation, bureaucracy, uncertainty and corruption.

That is, the regulation impacts on the UK construction industry supply chain innovation initiatives. In a recent global survey, regulation was identified as the most important driver of increasing complexity (Flyvbjerg, B, et al. 2003)

The UK construction industry is especially affected by changes in health and safety requirements, financial and labour legislation, and environmental standards. The new industry regulations in any of these areas can affect business operations adversely. If designed thoughtfully, however, regulation can actually prove advantageous to companies (Setar, 2013).

Lesta think of regulations not as imposing a burden but as offering opportunities to stimulate an industry transformation and inspire innovations that would greatly benefit the UK construction industry supply chain and the environment.

Lesta believes in involving the regulator earlier on in the process of supply chain innovative initiatives. For example, in some projects the partners are invited to participate in the project meetings. Practical solutions to work within the pre-existing regulations are developed jointly that incorporate ambitious innovations.

Some of Lesta's competitors are already gaining access in foreign countries and attempting to boost their market share. Lesta feels that when entering new countries, it could find that the best strategy might be to cooperate with local partners, via strategic partnerships, joint ventures, seek mergers and acquisitions.

In light of recent Brexit result and UK government's decision to leave Europe, it is important for the company to combine its own expertise with the local overseas partner's local construction industry supply chain knowledge and relationships. In some markets, the local authorities actually advise, request or even require such partnerships. Additionally, the value of local partners is particularly high in respect of understanding national or regional regulatory requirements, dealing with the local workforce, and negotiating a way through cultural or bureaucratic hurdles.

Lesta recognises that selecting a local construction industry supply chain partner is not easy since the real understanding of partner organisation and its construction industry supply chain knowledge may be unknown.

6.4.5. Regional Supply Chain Regulations for the Industry

According to Lesta, where the UK construction industry supply chain partners uses pre-fabricated materials and product there is a need for regional regulations.

Lesta believes in shaping the regulatory and market environment within the UK construction industry supply chain by enhancing its knowledge of 3D printing in construction. This will enable it and all partners to actively shape the regulatory environment; working closely with the UK construction industry supply chain, and regulators at regional and national level to revise as well as improve building codes.

Lesta emphasises the development of minimum viable products earlier on to demonstrate the power of technologies. In the absence of specific UK construction industry regulations, Lesta is not reluctant to create a viable and adaptable prototype which once accepted, could be recognised by the UK construction industry supply chain as innovative leadership.

6.4.6. Corrupt /Bureaucratic Environment

The challenge of corruption in the UK construction industry supply chain needs to be tackled according to Lesta leadership. For some projects within the UK construction industry supply chain, corruption remains potentially one of the greatest barriers to economic and social development. It was stressed by the Lesta management that the bribery and other forms of corruption could afflict almost every industry sector. This is a serious concern for the construction industry supply chain.

Lesta outlines that the issue of corruption on construction projects and therefore in the UK construction supply chain can only be determined or addressed through creation of a corruption-resilient industry procurement environment and implementing fair and transparent procurement procedures and establishing clear practices regarding the prosecution of corruption practices which addresses both the supply and demand sides of corruption.

For Lesta, the issue of bureaucracy remains a cause for concern. In some of the markets construction permits are subject to environmental and social-impact studies. However, where such studies are carried out inefficiently or if there is a backlog in the granting of permits, projects are usually delayed. This impacts cash-flow and therefore profit. In some cases even after the permits are granted, infrastructure projects remain vulnerable to cancellation, owing to the whims of national or local politics. Additionally, often, a new government sets different priorities from those of its predecessor and potentially resulting in wasted resources.

6.4.7. Informing the Conceptual Framework

Following the literature review as represented in the Figure 6.1., a theoretical themes framework is designed below in Figure 6.3.

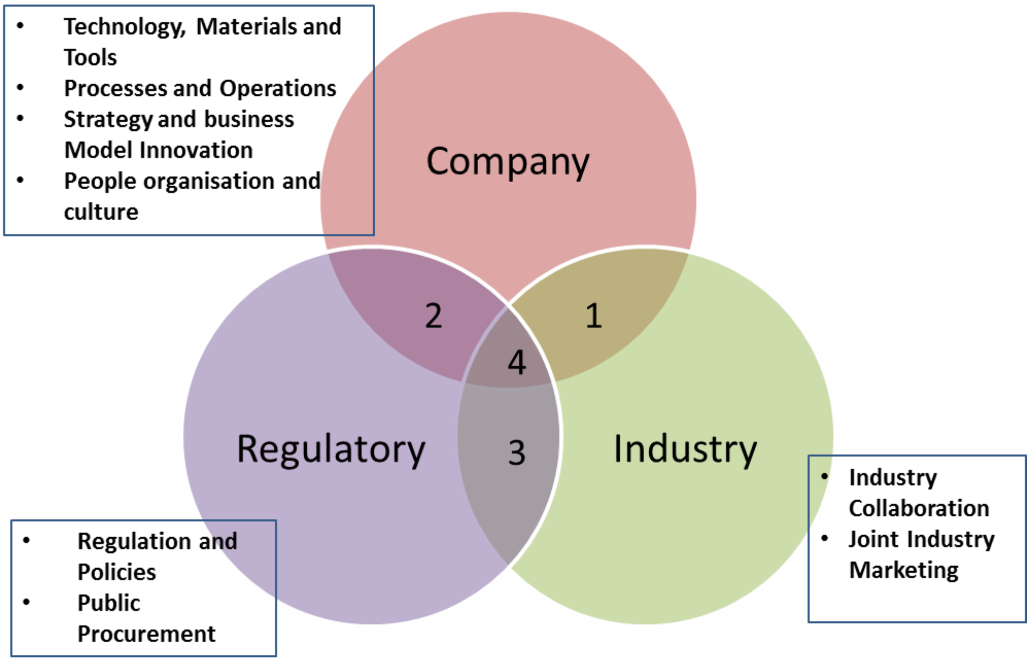

Figure 6.3 A new emerging conceptual frameworks

The three themes represented in the Figure 6.3. were developed as a result of further investigation into supply chain innovation with the input from the industry stakeholders.

The subsequent stage was to take forward the input from the industry stake holders and for each theme – company, industry and regulators, a number of variables were noted as represented in the Figure 6.4. below.

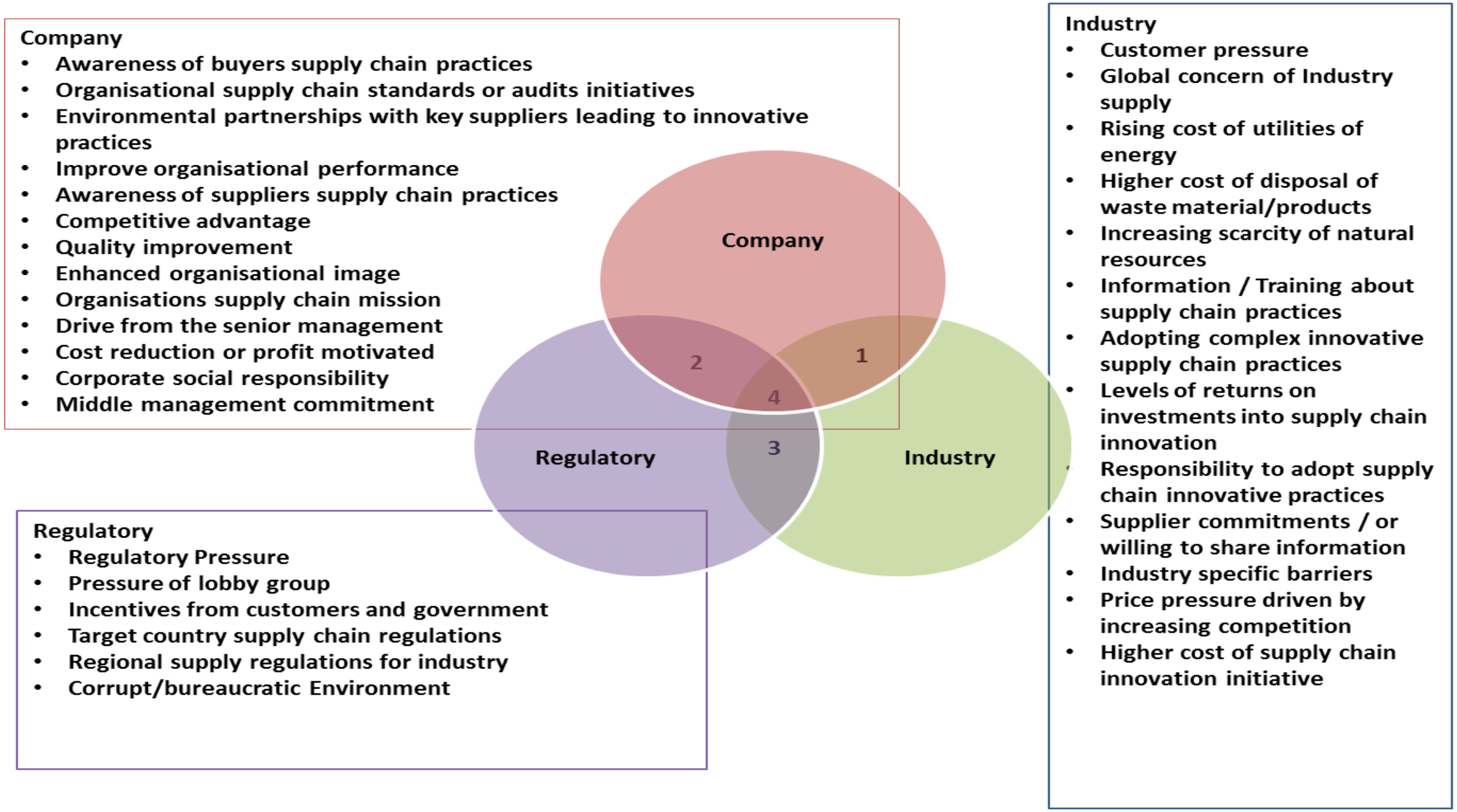

Figure 6.4 A new conceptual framework

6.4.8. Summarising the Case Study

It is clear from this case study that in the past, the UK construction industry building products manufacturers had put costs ahead of anything else. However, finance for the industry are not as readily available and the supply chain partner organisations such as Lesta are embracing new ways of working and the key words are low-carbon economy, circular economy and digital economy. As a result, it is clear for the UK construction industry supply chain that, for the domestic and overseas market, opportunities value is not only in the cash or availability of it.

Given that the building products manufacturers play a key role for the economy by contributing significantly to the GDP; this case study confirms that interworking between individual supply chain organisations, the industry bodies and the different regulators need to work in collaborative partnership.

More specifically, the building products manufacturers aiming to supply innovative products and solutions need to become forward looking by creating an innovative culture, introducing more flexible procurement, considering lifecycle costs rather than each projects and contracting models which provide the highest total value of ownership and not only contract the lowest cost.

The regulators on their part need to become smarter by harmonising and updating building codes and developing performance-based as well as forward looking industry standards for building products manufacturers.

The industry bodies representing the building products manufacturers need to take on the role of long-term strategic planner and incubator for innovation by adding values to products, markets or processes defining for the supply chain strategic innovation agenda, enabling investment in flagship projects and research and development; and supporting start-up finances.

This case study confirms that at the industry level there is a need for taking ownership of the issues not only on organisations but regulations; sponsorship of innovation practices; take on the role of industry leadership; collecting the real data evidence for the industry; and development for the building products manufacturers narrative for innovative products/materials practices.

Chapter Seven
Conclusions, Limitations and Recommendations for Future

7.1. Summarising the Research

This chapter summarises the research findings and therefore brings together the literature review, the methodology used for the research, the data verification, the case study and the formation of a conceptual framework.

Through this research study, all of the aims and objectives considered for this work have been satisfied and the conclusions from this study are presented in this chapter.

7.2. The Objectives

The main aim of this study was to inform the development of a conceptual framework that could be used by policy makers to enhance the understanding and role of innovative supply chain processes and/or practices in the sustainability of the UK construction industry.

In order to achieve this aim, the following objectives were undertaken:

1. Examine the key elements of innovative processes and/or practices within the UK construction industry Supply Chain;
2. Review the relevant literature and identify emerging gaps in adopting innovative processes and/or practices in the UK construction industry;
3. Identify the key parameters, drivers and barriers in adopting innovative supply chain processes and/or practices within the UK construction industry;
4. Establish the extent to which UK industry management practices, organisational performances have contributed to sustainability;
5. Provide best practice framework to guide the construction industry professionals in designing and adopting innovative supply chain in the UK construction industry.

These objectives were addressed through the lenses of a number of key stakeholders as follows:

- Objectives 1, 3 and 4 – UK construction industry Supply Chain Organisations
- Objectives 2 and 5 – Academics, Supply Chain practitioners and Policy Makers

7.3. The Research Questions

- What are the key elements of Innovative practices and/or processes within the UK construction industry Supply Chain?
- What are the key parameters, drivers and barriers in adopting innovative supply chain practices within the UK construction industry?
- What are the predominant management practices and organisational performances that have contributed to the UK construction industry in the last 10 years?
- What are the key bodies of literature and gaps in the Innovative practices and/or processes in the UK construction industry?
- What are the best practice models to guide the construction industry professionals in designing and adopting Innovative Supply Chain in the UK construction industry?

7.4. Informing the development of a Conceptual Framework

The conceptual framework was designed using the literature review as represented in the Figure 7.1

. The next stage was to zoom into the supply chain innovation and three themes were developed with the input from the industry stakeholders. This is represented in the Figure 7.2.

The next stage was to take forward the input from the industry stake holders and for each theme – company, industry and regulators a number of variables were noted as represented in the Figure 7.1.

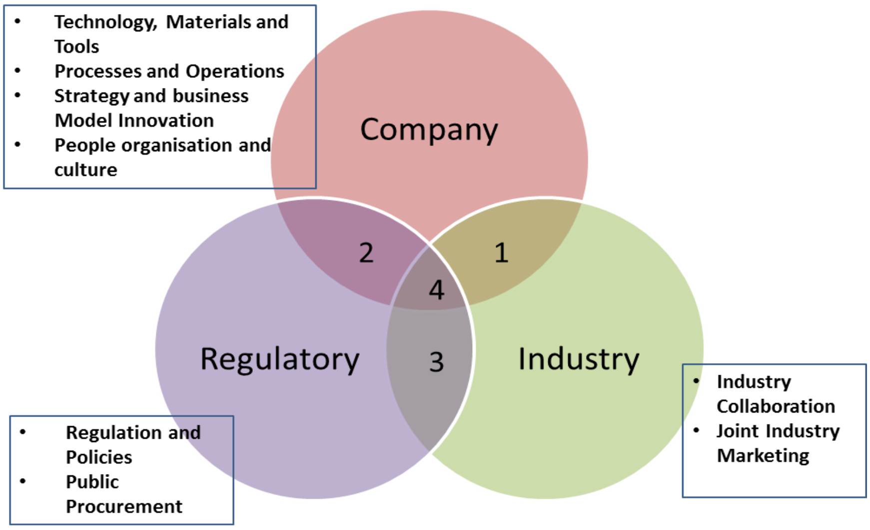

Figure 7.1 A new Conceptual framework

7.5. A new Conceptual Framework Focus Areas

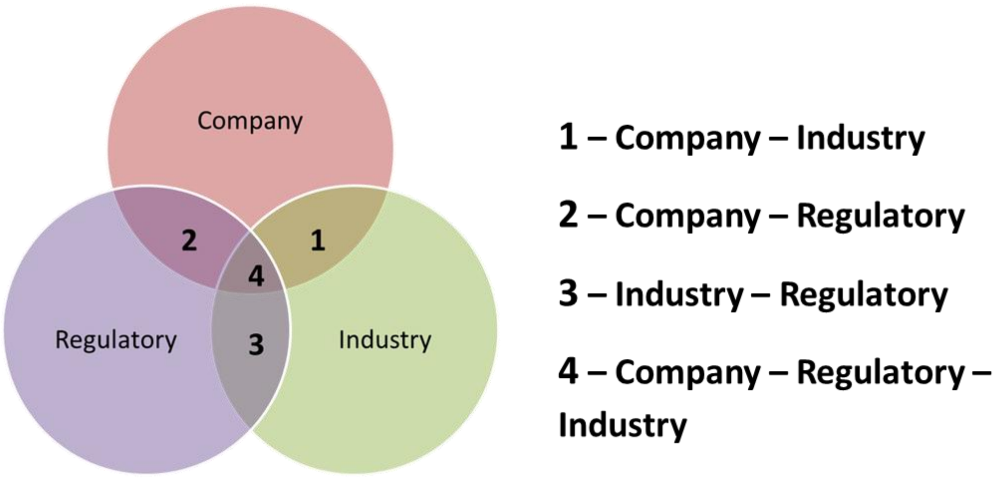

Figure 7.2 A new conceptual framework interactions

7.6. Contribution to Knowledge

For this research study we have sought to enhance and improve understanding of the role of innovative supply chain processes and/or practices in improving the sustainability of the UK construction industry.

The Literature review, the data analysis and the case study evidence have served to identify a number of challenges faced by the UK construction industry supply chain. That is to highlight, the high level of the UK construction industry supply chain fragmentation; reluctance to adopt innovative practices; failure to attract best professional, ageing workforce and declining skills base; failure to own and manage supply chain risks instead of passing on the burden to partners; lack of coherent industry led adoption as well as promotion of innovative materials/products practices; and contract tendering/bidding practices within the industry limiting innovative collaborations with suppliers and customers.

The evidence is reflected in the Figure 7.2 above; which shows the levels of interaction together with the brief summary of challenges facing the UK construction industry and the consumers.

7.6.1. Interaction between Company – Industry

- The building products manufacturers have confirmed the need for proactive engagement and decisive engagement which will act to reduce the risks and aid business growth.
- For economies of scale, quality improvements, specialisations, better skills access and innovative specialisation for the supply chain participants and skills access; there is need for building products manufacturers to remain receptive to competition.
- The proactive supply chain innovation of materials and products by building products manufacturers will lead to acceptance of innovation, improved quality of products, cost/revenues performance and timescales and this will contribute to improved construction industry supply chain.

- The building products manufacturers recognise that to become significant market players in the UK construction industry, there is a need for continuously evaluating the relationships with the suppliers and customers to reduce the operational costs, improve quality and reduce lead times through managing complexity of delivering innovative supply chain products.
- The industry and private company partnerships must take on added responsibility of encouraging and maintaining an innovative supply chain partnership approach; and this would lead to additional business growth.
- The building products manufacturers must develop and maintain clear vision; best value sourcing of innovative products and services; and maintain environmental, social and ethical requirements in the sustainable supply chain process.
- The building product manufacturers must recognise their responsibility towards industry sustainability while remaining competitive through nurturing supply chain relationships; and sharpening strategic focus on high-growth emerging market opportunities as well as local infrastructure opportunities.
- The building products manufacturers must recognise that the legacy products, infrastructure and IT systems in the UK construction industry supply chain are hindering or holding technology adoption back and therefore creating barriers to speed of digital technologies adoption as well as lowering profit margins.
- Currently some of the building products manufacturers do not consider that they have direct responsibility for industry sustainability; many don’t even consider industry sustainability is crucial.
- For the building products manufacturing industry and companies collaboration the middle managers responsible for managing the products developments, adopting supply chain best practice processes, strategic decision making and projects remain motivated and sufficiently trained.
- The building products manufacturers within the UK construction industry supply chain must cooperate with the supply chain players and develop appropriate

innovative solutions and consider new/additional revenue streams for its customers too.

- The building products manufacturers for introducing innovative practices/products must learn to forward plan and not be driven by the cyclical nature of the UK construction industry; and this is crucial for overcoming significant challenges associated with purchasing of construction materials and products.
- The building products manufacturers in partnership with the UK construction industry develop a supplier code and ensure that code is communicated, understood and adopted by different functions in the supply chain for inter-organisation as well as intra-organisation customer-supplier links.

7.6.2. Interaction between Company – Regulatory

- The building products manufacturers and the regulators partnership must be improved for efficient and effective regulatory frameworks.
- Active regulatory support is needed by the building products manufacturers for encouraging collaboration, integrating the product innovations and its functionalities into the buildings without increasing cost burdens and reducing the risks associated with the new technologies.
- The strong industry-regulatory partnerships building products supply chain is necessary to acknowledge that the real value is in improving the construction processes and adopting the innovative materials resulting in improved product quality in building projects; and this would lead to reduced costs, a healthy environment for the building users and improved industry sustainability.
- The regulators must ensure that the long-term commitment in using natural resources should be accompanied by a transparent, fair and regularly revised evaluation of the suppliers of the building products within the UK construction industry supply chain.
- The building products manufacturers must partner with design institutes regulated by the UK regulatory authorities to engage and work with designers and architects

since they are key agents in promoting the innovative materials and innovative technology led solutions.

- The regulatory and building products manufacturing partnership must develop regulatory guidance to ensure that advanced building materials with cutting edge innovation achieve deserved acceptance and overcome higher initial investment required with payback spread over lifetime of the project.
- The building products manufacturers require the regulatory guidance to create next generation knowledge since most of the UK construction sector supply chain training is geared towards sustaining existing or familiar material; most of the training is designed around existing material and not much around innovative materials; amongst manufacturing SMEs there is lack of resources to proactively encourage innovation individually.
- The regulatory and building products manufacturers need to recognise the responsibility of the UK construction industry through supply chain innovation practices; and continuously address issues around the technical knowledge/training gaps and maintain awareness of the potentially negative perceptions amongst the industry professionals.
- For the building products manufacturers, the partnership with the regulatory authority is crucial for designing regulations which could influence multidisciplinary, multifunctional and multitalented teams to overcome barriers which are the results of functional thinking and not based on cross-functional practices.
- The regulator and the building products manufacturers must jointly overcome the belief that there is poor regulatory guidance for the UK construction industry supply chain practices for adopting innovative materials or designing new products.
- For the building products manufacturers to understand the full potential of innovative solutions and cost-conscious design and project planning, it is important to involve all supply chain suppliers and subcontractors; and crucially regulatory support is required for meeting full legal compliance for both short/longer term

business benefits; ensuring equal treatment of all projects bidders; and operating a forceful regulatory system.

- The UK construction industry supply chain players believes that the regulatory partnership needs to be more proactive because of the fragmented nature of the supply chain of the UK construction industry and focus on project to projects costs.

7.6.3. Interaction between Regulatory – Industry

- For the building products manufacturers in the supply chain believe that the regulations must be shaped in partnership between the regulators and the industry bodies representing the manufacturers.
- The building products manufacturing representatives and the industry regulators must seek to work together to adopt new innovative technologies, new ways of working, to overcome resistance where the regulations are concerned through development/adoption of regulatory framework.
- The building products manufacturers must be encouraged to consider different models and through strong regulatory guidance, help ensure the critical success factors for the projects such as alignment, incentives, collaboration, integrated teams, visible programmes and minimizing of waste are proactively identified.
- The building products manufacturers need to widen the consideration that the industry regulations are not seen as imposing a burden but as offering opportunities to stimulate transformation and inspire innovations that benefit industry and the environment to improve building codes.
- The building products manufacturers maintain that the issue of corruption on construction projects can only be determined or addressed through creation of a corruption-resilient industry procurement environment ultimately owned by the regulators implementing fair and transparent procurement procedures; establishing clear procedures regarding the prosecution of corruption practices in the supply chain; and in helping overcoming concerns around bureaucracy.

7.6.4. Interaction between Company – Regulatory – Industry

- The hypothesis tests to measure the contribution of company, industrial and regulatory factors in positively affecting key elements of innovative supply chain; confirmed that there is not much impact.
- The hypothesis to test whether the company, industrial and regulatory factors positively impact supply chain management practices led to conclusions that there was no significant impact.
- Inward focused project management practices rather than collaborative and expansive thinking is limiting the innovation for the building products manufacturers within the UK construction industry supply chain.
- The hypothesis to test whether the company, industrial and regulatory factors positively influence impact of organisational processes and management practices on supply chain led to conclusion that there was not much influence.
- For the building products manufacturers to make significant contribution to the UK construction industry sustainability they need to innovate for the carbon reduction and waste reduction in the supply chain links.
- The hypothesis to test whether the key organisational practices influence positively cost and waste reductions led to the conclusions that there is not much influence.
- The hypothesis to test whether the company, industrial and regulatory factors positively affect lean application and adoption in design and product / materials development process proved that there was no effect.
- Current building products manufacturers supply chain practices continue to fuel the fragmentation; and majority of the partners/manufacturers within the UK construction industry supply chain are engaging on the project by project basis.
- The hypothesis to test whether the company, industrial and regulatory factors positively influence innovative marketing led to conclusions that there is some influence.

- Due to lack of coherent marketing and promotion of innovative material or products jointly led by – organisations, industry and regulator – the UK construction industry supply chain struggles to supply innovative products with new materials and specially fails to manage customers' expectations.
- The hypothesis to test whether the company, industrial and regulatory factors positively impact customer engagement practices led to the conclusion that there was not much influence.
- This research study has confirmed that for the building products manufacturers in the UK construction industry supply chain the product innovation from new or improved materials is a must requirement; and the suppliers must focus on developing products strategy where the product innovation is viewed as a key part of longer term business strategy.
- This research has confirmed that for a typical construction project there are many different suppliers involved and these organisations are normally SMEs; there is a need for building products suppliers in the UK construction industry supply chain to adopt proactive innovation through developing or designing cross-functional structures so that intra-organisational performances in the supply chain can be improved.
- The innovation needs for new technologies and communications devices means there is a need for company-industry-regulators to adopt an innovative business model by innovating the building products manufacturing relating to the teams, tools and processes or systems.
- The hypothesis to test whether the company, industrial and regulatory factors positively influence, through economic environment, on product innovation process confirmed that there was not much influence.
- The hypothesis to test whether the key organisational practices, positively influencing improvements in economic gains, led to the conclusions that there was no significant influence.

- This research has identified the need for building manufacturers to develop different customers' perspective in the UK construction industry supply chain.
- The hypothesis tests to measure whether the company, industrial and regulatory factors positively affect innovative product design practices, proved that there is some impact.
- The hypothesis to test whether the company, industrial and regulatory factors positively affect lean adoption and application in supply chain led to conclusions that there is some evidence of effect.
- The hypothesis to test whether the company, industrial and regulatory factors positively affect lean adoption in supply chain of product production process led to conclusions that there is some evidence of effect.
- This research has identified the need for the building products manufacturers, the regulators and the wider UK construction industry stakeholders to develop partnerships approach to design/create an industry best practice models that includes and encourages practical adoption of innovative new materials.
- This research has confirmed that the building products suppliers encounter barriers in the UK construction industry supply chain and therefore the manufacturers, industry and regulators must learn to function collaboratively; articulate a vision for the UK construction industry supply chain and promote a culture of innovation amongst the building products suppliers.
- This research has identified the need for the different regulatory bodies within the UK construction industry bodies to coordinate all activities coherently with the industry and its members consistently in order to motivate and promote innovative practices for the UK construction industry supply chain building products manufacturers.
- The hypothesis to test whether the company, industrial and regulatory factors positively affect innovative production/operational efficiencies suggest there was evidence of some impact.

- This research has identified the need for cultivating the wider ecosystem to implement innovation in products, operations and new markets for the building products manufacturers in the UK Construction industry supply chain partnerships.
- The hypothesis to test whether the building products manufacturers key organisational practices positively influenced improvements in Business efficiencies, led to the belief that there was no influence.
- The hypothesis to test whether the company, industrial and regulatory factors positively affected use of reverse logistics practice led to conclusions that there was not much influence.
- The hypothesis to test whether the company, industrial and regulatory factors positively affected semi-automated equipment adoption led to conclusions that there was not much impact.
- The supply chain tend to operate from project to project principles and practice on site construction processes; there is a failure to share knowledge and engage more proactively quickly as well as decisively; additionally, different levels of risk burden is passed on to the supply chain participants in the value chain; and this attitude on part of the supply chain partners leads to failure in collaborations for innovation in terms of new products, or operations or new markets.
- The hypothesis to test whether the key organisational practices had positively influenced improvements in compliance led to the conclusions that there was not much influence.
- The hypothesis to test whether the key organisational practices influence improvements in sustainability and environmental image, led to the evidence that there was no influence.

7.7. Limitations of this Research Study

The limitations of this research study are summarised below:

- This research study context is limited to the UK construction industry and therefore, it is not possible to apply its findings globally without carrying out similar study in the other countries.
- The survey questionnaire was based on a number of literature themes and future researchers might chose to add or include alternative themes for the studies as well as choose to include wider industry organisations to test the insights.
- The single case study could be a source of criticism for offering a low level of generalisation without additional research. However, considering the supply chain innovation initiatives impact the industry practices, this holistic case study was chosen to consider all relevant innovation drivers as well as barriers.
- One suggestion for future research is to include more case studies in the supply chain of the UK construction industry, inclusion of non-manufacturing representative and collection of relevant data could help to validate the conceptual framework.
- Other suggestion is to include more supply chain organisations for collecting data and not just the manufacturers from the UK construction industry supply chain; this could serve to increase the reliability and validity of this research study.
- The proposed conceptual framework is still unique and very generic; therefore, for wider deployments or industry application it would require modifications when considered for different construction projects or application to other industries.

7.8. Emerging Themes for the Future Research

There are several themes which emerge and therefore, can be pursued while using this study as a starting point:

- Since some of the challenges for effective and efficient supply chain innovation initiatives within the UK Construction industry include issues around risks sharing and trust; these can be further investigated or examined to identify the factors around these challenges; the level of motivations, incentives between different supply chain organisations can be investigated too.

- The role of the industry regulatory bodies and support infrastructure as far as supply chain innovation practices are concerned can be examined or investigated.
- Future studies could include more focus on business benefits as a result of supply chain initiatives within the UK construction industry.
- Consider the similar study in the other industrial settings to test the proposed knowledge and using this study as a starting point.
- The management practices impact of skills gap, lack of reception to technologies led innovation and ageing workforce within the UK construction industry could be source of further study.
- Validation of the proposed conceptual framework in this research study could be a subject of future research.

Appendix A: Questionnaire

Questionnaire supply chain innovation for delivering sustainable construction

The main aim of this study is to develop a conceptual framework that can be used by policy makers to enhance the understanding and improve role of innovative supply chain processes and/or practices in improving the sustainability of the UK construction industry.

In order to achieve this aim, the following objectives would be undertaken:

1. Examine the key elements of innovative processes and/or practices within the UK construction industry Supply Chain.

2. Review the relevant literature and identify emerging gaps in adopting innovative processes and/or practices in the UK construction industry.

3. Identify the key parameters, drivers and barriers in adopting innovative supply chain processes and/or practices within the UK construction industry.

4. Establish the extent to which UK industry management practices, organisational performances have contributed to sustainability.

5. Provide best practice Framework to guide the construction industry professionals in designing and adopting Innovative Supply Chain in the UK construction industry.

There are five main research questions to be addressed by this study through the stakeholders.

1. What are the key elements of Innovative practices and/or processes within the UK construction industry Supply Chain?

2. What are the key parameters, drivers and barriers in adopting innovative supply chain practices within the UK construction industry?

3. What are the predominant management practices and organisational performances that have contributed to the UK construction industry in the last 10 years?

4. What are the key bodies of literature and gaps in the Innovative practices and/or processes in the UK construction industry?

5. What are the best practice models to guide the construction industry professionals in designing and adopting Innovative Supply Chain in the UK construction industry?

Answers to questions one to three will be explored through surveys with UK construction industry Supply Chain Organisations, whilst that for questions four to five would be undertaken with academics and policy makers.

Questionnaire for the UK construction industry Supply Chain Organisations

Please answer the questions below with reference to your organisations innovative supply chain practices. We understand that you may decide to discuss the questionnaire with your colleagues in the organisation and we encourage that.

Let me assure you at the outset that all the questions given by you will remain strictly confidential. That is, neither you nor your organisation will be identified – only aggregate results will be published.

Please remember that there are no right or wrong answers for the purpose of research evaluation. In simple terms, I need your evaluation of the intensity of involvement by an organisation in the following activities and practices.

Personal/Business Details

Name of Company:

Tel: Email:

Name of respondent/interviewee:

Position: Contact details:

Length of service in the Construction Industry:

Background/history of relevance in the Industry:

How would you describe your organisation?

- Supplier
- Contractor
- End user

How many people are employed in your organisation?

- Less than 100
- 100 – 500
- 500 – 1000
- More than 1000

What is approximate investment in plant and machinery in your organisation?

- Less than £1m
- £1 - £10m
- £10m - £50m

- More than £50m

2.0 Key elements of Innovative practices and/or processes

2.1 Please indicate the status of the following innovative supply chain practices in your organisation (please tick one in each row: 1 – Never Used; 2 – Rarely Used; 3 – Sometimes Used; 4 – Sometimes Used; 5 – Frequently Used; 6 – Always Used)

	Innovative supply chain practices	1	2	3	4	5
1	Work with industry suppliers to improve their supply chain practices					
2	Purchase products that have innovative attributes					
3	Working with suppliers to innovate supply chain through product design and material usage					
4	Auditing suppliers to evaluate their environmental performance					
5	Encouraging suppliers to have ISO14001 certification					
6	Evaluating suppliers supply chain practices					
7	Organising workshops/ seminars for suppliers on innovative supply chain practices					
8	Bringing together suppliers in the industry to share their expertise and problems					
9	Choice of suppliers by innovative supply chain practices criteria					
10	Sharing technical expertise with suppliers adopting Innovative practices					
11	Participating in the design of products for packaging					
12	Participating in the design of products for recycling or reuse					
13	Ensuring supplier to commit to reduce waste by adopting innovation					
14	Use lifecycle analysis to measure the innovation within the products and packaging					
15	Recognitions and awards for innovative supply chain practitioners					
16	Any other please specify					

2.2 Please indicate the relevance of the following innovative product design practices for your organisation (please tick one in each row: 1 – Never Used; 2 – Rarely Used; 3 – Sometimes Used; 4 – Sometimes Used; 5 – Frequently Used; 6 – Always Used)

	Innovative product design practices	1	2	3	4	5
1	Adopting new material for products					

2	Designing innovative products to reduce consumption of energy					
3	Designing innovative products to reduce emission					
4	Innovative design of products for reuse, recycle, recovery of material and sub-assembly products					
5	Using lifecycle analysis for products					
6	Innovative design for reduced waste generation / material consumption					
7	Any other please specify					

2.3 Please indicate to what extent your organisation adopt the Lean practices in design and development of products and materials in your organization (Please tick one in each row)
(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – Very Important, 5 – Extremely Important)

	Lean application and adoption in design and product / materials development process	1	2	3	4	5
1	Design is informed by extensive data on performance of products, systems and components					
2	Carry-over to new models of a high proportion of systems and components from previous model					
3	Front-loading of resources towards design to prevent problems during manufacturing					
4	Concurrent working between manufacturer and supplier during design development					
5	Use of visualization techniques such as virtual reality and 3D CAD to fully define the product requirements from the customer's perspective					
6	Value management to achieve more understanding and focus on client value					
7	Use of integrated design and build arrangements – such as partnering – to encourage close cooperation between designers, constructors and specialist suppliers					
8	Design for standardization and pre-assembly processes and product components to achieve higher quality, cost and time savings					

2.4 Please indicate the status of the following innovative products production practices in your organisation (please tick one in each row: 1 – Never Used; 2 – Rarely Used; 3 – Sometimes Used; 4 – Sometimes Used; 5 – Frequently Used; 6 – Always Used)

	Innovative Products Production / operations Practices	1	2	3	4	5

1	Modify production/operation processes to reduce supply chain solid waste					
2	Modify production/operation processes to reduce supply chain liquid waste					
3	Modify production/operation processes to reduce carbon emission					
4	Use innovative cleaner technology to save energy, waste etc.					
5	Recycling organisational supply chain waste					
6	Interdepartmental Cooperation for innovative improvements in the supply chain					
7	Production and operational planning and control focused on reducing waste optimising innovative materials exploitation					
8	Any other please specify					

3.0 Key parameters, drivers and barriers in adopting innovative supply chain processes and/or practices

3.1 Please indicate how you would perceive the following factors for innovative supply chain practices for your organisation (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – Very Important, 5 – Extremely Important)

	Main Drivers Behind Innovative Supply Chain	1	2	3	4	5
1	Regulatory pressure					
2	Customer pressure					
3	Improve organisational performance					
4	Competitive advantage					
5	Pressure of lobby group					
6	Incentives from customers and government					
7	Global concern of Industry supply					
8	Quality improvement					
9	Target country supply chain regulations					
10	Enhanced organisational image					
11	Environmental partnerships with key suppliers leading to innovative practices					
12	Organisations supply chain mission					
13	Drive from the senior management					
14	Cost reduction or profit motivated					
15	Rising cost of utilities of energy					
16	Higher cost of disposal of waste material/products					
17	Corporate social responsibility					
18	Increasing scarcity of natural resources					

3.2 Please indicate the main obstacles to Innovative supply chain practices for your organisation (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – very Important, 5 – Extremely Important)

	Main Barriers	1	2	3	4	5
1	Lack of information / Lack of training about supply chain practices					
2	Innovative practices too complex to adopt					
3	Low returns of investments into supply chain innovation					
4	Not organisations responsibility to adopt supply chain innovative practices					
5	Higher cost of supply chain innovation initiatives					
6	Poor supplier commitments / or Unwilling to share information					
7	Industry specific barriers					
8	Price pressure driven by increasing competition					
9	Lack of management commitment					
10	Poor awareness of buyers supply chain practices					
11	Poor awareness of suppliers supply chain practices					
12	Poor organisational supply chain standards or audits initiatives					
13	Poor regional supply chain regulations for the industry					
14	Poor national supply chain regulations for the industry					
15	Corrupt /bureaucratic environment					

4.0 Impact on supply chain innovations

4.1 Please assess impact of economic environment on supply chain in your organisation (please tick one in each row: 1 – Never; 2 – Rarely; 3 – Sometimes; 4 – Sometimes Used; 5 – Frequently; 6 – Always)

	Impact of economic environment on Product Innovation practices	1	2	3	4	5
1	Country environment affects the type of product innovation in the company					
2	Continue product innovation in uncertain end changing environment					
3	Technological environment impacts product innovation					
4	Diversity in external environment impacts product innovation					
5	Product innovation dynamism driven by external environment					

4.2 Please assess impact of organisational processes and management practices on supply chain in your organisation (please tick one in each row: 1 – Never; 2 – Rarely; 3 – Sometimes; 4 – Sometimes; 5 – Frequently; 6 – Always)

	Impact of organisational processes on Product Innovation practices	1	2	3	4	5
1	Product innovation impacted by competition and aggression					
2	Impact of organisational size and impact on product innovation					
4	Impact of marketing orientation on the product innovation					
5	Impact of board or senior management diversity on product innovation					
6	Organisational power structure impacts on product innovation					
8	CEO and top management work together to response to environment and identify new innovative products					
9	CEO characteristics, and personal attributes matter					
10	Link between overall strategy, the process of strategy development and product innovation matters					
11	CEO creates models to follow and style product innovation					
12	CEO creates informal structural mechanisms					
13	CEO creates product innovation teams					
14	CEO creates creativity friendly climate					
15	CEO creates systems to recognise early breakthroughs and recognition of opportunity					
16	Recognition of importance of team composition, format and structure for Product Innovation					
17	Leadership style matters in product innovation					
18	Adoption of communication between team members and problem solving procedures					
19	Methods of communications for effective information sharing with management					

4.3 Please indicate the influence of the customers on the organisational culture (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – very Important, 5 – Extremely Important)

	Customer Engagement	1	2	3	4	5
1	Our business objectives are driven primarily by customer satisfaction					
2	We constantly monitor our level of commitment and orientation to serving customer needs					

3	We freely communicate information about our successful and unsuccessful customer experiences across all business functions					
4	Our strategy for competitive advantage is based on our understanding of customers' needs.					
5	We measure customer satisfaction systematically and frequently					
6	We have routine or regular measures of customer service					
7	We are more customers focused than our competitors.					
8	We believe this business exists primarily to serve customers					
9	We poll end user's at least once a year to assess the quality of our products and services					
10	Data on customer satisfaction are disseminated at all levels in this business unit on a regular basis					

5.0 Management practices and organisational performances that have contributed to the UK construction industry within the last 10 years

5.1 For Innovative supply chain management please indicate the adoption of the following practices in your organisation (please tick one in each row: 1 – Never Used; 2 – Rarely Used; 3 – Sometimes Used; 4 – Sometimes Used; 5 – Frequently Used; 6 – Always Used)

	Innovative supply chain management practices	1	2	3	4	5
1	ISO14001 certification					
2	Interdepartmental cooperation for supply chain improvements					
3	Supply chain compliance and auditing programmes					
4	Supply chain policy					
5	Supply chain training and awareness programme for employees					
6	Disclosure or sharing of supply chain practices records					
7	Rewards and incentives for the employees demonstrating Innovative supply chain ideas /initiatives					
8	Commitment from the top management for innovative practices in the supply chain					
9	Any other please specify					

5.2 Innovative marketing, please indicate the status of following practices in your organisation (please tick one in each row: 1 – Never Used; 2 – Rarely Used; 3 – Sometimes Used; 4 – Sometimes Used; 5 – Frequently Used; 6 – Always Used)

	Innovative Marketing	1	2	3	4	5

1	Using innovative packaging					
2	Recollecting the Packaging					
3	Purchase recycled packaging					
4	Recovery of company's end of life products					
5	Eco-labelling products					
6	Any other, please specify					

5.3 How do you perceive the influence of innovative supply chain practices on the following firm performance parameters (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – very Important, 5 – Extremely Important)

	Performance Measure	1	2	3	4	5
1	Supply chain compliance improvement					
2	Reduce environmental discharge through innovative supply chain practices					
3	Decrease in consumption of hazardous material through innovative practices					
4	Reduction in waste through innovative supply chain practices					
5	Improve recycling of products and materials through innovative supply chain practices					
6	Reduction in frequency of environmental incidents/accidents through innovative supply chain practices					
7	Improvement in environmental quality of products / services through innovative supply chain practices					
8	Productivity improvements through supply chain innovation					
9	Cost reduction as a result of innovative supply chain practices					
10	innovative supply chain practices leading to increased energy efficiency					
11	Investment recovery through sale of additional inventories and materials through innovation in supply chain					
12	Increase in the market share as a result of innovative supply chain practices					
13	Increased profit margins as a result of innovative supply chain practices					
14	Improve brand image through innovative supply chain practices					

5.4 For Innovation in the supply chain, please indicate the status of the following practices in your organisation (please tick one in each row: 1 – Never Used; 2 – Rarely Used; 3 – Sometimes Used; 4 – Sometimes Used; 5 – Frequently Used; 6 – Always Used)

	Innovative supply chain logistics practices	1	2	3	4	5

1	Use of reverse logistics					
2	Using innovative supply chain friendly transportation					
3	Innovative supply chain innovative consolidation					
4	Using nearby supply chain sources					
5	Use of standardised reusable containers / packaging in innovative supply chain logistics practices					
6	Lack of reliance on formal contracts					
7	The use of benchmarking of suppliers' performance against each other on a range of generic criteria					
8	The development of close relations with first tier suppliers					
9	Just-in-time delivery of materials to the point of to eliminate the need for on-site storage and double-handling					

5.5 Use of Semi-automated construction equipment for supply chain processes in our organisation (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – very Important, 5 – Extremely Important)

	Semi-automated equipment adoption	1	2	3	4	5
1	Semi-automated equipment reduces construction costs					
2	Semi-automated equipment improves productivity due to shorter delivery times					
3	Semi-automated equipment provides higher quality by reducing workmanship errors and higher accuracy					
4	Semi-automated equipment improves safety by allowing workers to stay out of danger zone					

5.6 Lean thinking in supply chain for construction project management (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – very Important, 5 – Extremely Important)

	Lean adoption and application in supply chain	1	2	3	4	5
1	Clear communication and project plans					
2	Training, teamwork and multitasking					
3	Daily progress reporting and improvement meetings					
4	Improving the flow of work on site by defining units of production and using tools such as visual control of processes					

5	Using dedicated design teams working exclusively on one design from beginning to end and developing a tools to significantly speed up design process					
6	Innovating in design and assembly through the use of fabricated brick infill panels manufactured off site and pre-assembled roofs lifted in to place					
7	Supporting sub-contractors in developing tools for improving processes					
8	Pre-fabricated assembly improves quality control and reduced time on site					
9	Pre-fabricated assembly reduces need for storage on-site of equipment, disruptions, labour costs, noise and waste					
10	Improves control of supply chain, reliably and continuous improvements through feedback loops					
11	Resource efficient and improves control of costs and site productivity					
12	Reduced environmental impact through reduced wastage in manufacturing and on-site					

5.7 Lean Production and planning in supply chain for construction projects in our Company (Please tick one in each row)

(1 – Unimportant, 2 – Somewhat Important, 3 –Important, 4 – very Important, 5 – Extremely Important)

	Lean adoption in supply chain of product production process and planning	1	2	3	4	5
1	In depth understanding of production processes and resources involved in them					
2	Responsibility and authority placed with the Workforce staff					
3	Real-time feedback on the performance					
4	Benchmarking to establish 'best in class' production methods and outputs					
5	Establishment of a stable project programme, with clear identification of critical path					
6	Risk management throughout the project					

References

Abele, E., Anderl, R. and Birkhofer, H. (2005), Environmentally-friendly product development - methods and tools; London; Springer-Verlag.

Acton, A. Q. (2012), 'Issues in Environmental Economics, Engineering, and Technology', Scholarly Editions Publishers, USA.

Adams, W. M. (1990), 'Green Development: Environment and sustainability in the third world'.

Adamson, D. A. and Pollington, T. (2006), 'Change in the Construction Industry: An Account of the UK Construction Industry Reform Movement 1993-2003', Routledge Publication, UK, p.140-151.

Addis, B. (2012), 'Building with Reclaimed Components and Materials; A Design Handbook for Reuse and Recycling', Routledge Publications, USA, p.55-82.

Adetunji, I., Price, A., and Fleming, P. (2008), Achieving sustainability in the construction supply chain. Proceedings of the ICE - Engineering Sustainability, 161 (3), pp. 161 - 172

Adeyeye, K., Osmani, M., and Brown, C. (2007), Energy conservation and building design: the environmental legislation Push and Pull factors. Structural Survey, 25(5), 375-390.

Ahmed, V. and Opoku, A. (2015), 'Drivers and Challenges to the Adoption of Sustainable Construction Practices', In Ahmed, V. and Opoku, A, Leadership and Sustainability in the Built Environment, Routledge Publication, UK, p.69-78.

Alam et al. (2010), the Conceptual Lean PPD Model, New World Situation: New Directions in Concurrent Engineering, pp 339-346.

Alashwal, M., Rahman, H. A. and Beksin, A. M. (2011), Knowledge sharing in a fragmented construction industry: On the hindsight. Construction, 6(7), 1530–1536.

Albanesius, C. (2013), Android Fragmentation Has Its Benefits, Report Says. PC Magazine.

Alexander, M. and Mindess, S. (2010), 'Aggregates in Concrete: Modern Concrete Technology', CRC Publication, UK, p.5-47.

Allen, K. (2013), UK construction output highest since September 2007. The Guardian; Available at: http://www.theguardian.com/business/2013/nov/04/uk-construction-output-property-market.

Alonso, S. (2012), 'Challenging the State: Devolution and the Battle for Partisan Credibility', Oxford University Press, UK, p.90-95.

Appleby, P. (2012), 'Integrated Sustainable Designs of Buildings', Routledge Publication, UK, p.-355-399.

Arditi, D. et al (1985), 'Reasons for delays in public projects in Turkey, Construction Management and Economics Vol.3.

Argote, L and Ingram, P (2000), Knowledge transfer: A basis for competitive advantage in firms, Organizational Behaviour and Human Decision Processes, 82 (1): 150- 169.

Asiedu, W. G. and Scheublin, F. et al. (2007), 'Performance Assessment for Sustainable Construction, in Braganca, L. et al, Portugal SBo7 Sustainable Construction Materials practices: Challenges of the Industry for the New Millennium, IOS Press Netherlands.

Atkinson, G. (2008), Sustainability, the capital approach and the built environment. Building Research and Information, 36(3), 241-247.

Awasthi, A., Grzybowska, K. (2014), Barriers of the Supply Chain Integration Process, Logistics Operations, Supply Chain Management and Sustainability, p. 15.

Aydin, E. (2013), 'The Effect of Individual Creativity on Ecopreneurship: Creativity, Entrepreneurship, Ecopreneurship', Lambert Academic Publishers, Germany, p.5-12.

Ayikoru, M. (2009), Epistemology, Ontology and Tourism; In Tribe, J. (ed.) Philosophical Issues in Tourism, pp. 62-79.

Babbie, E. (2007), Conducting qualitative field research. In The practice of social research (11th ed.). U.S.A.: Thomson Wadsworth.

Bain & Company (2015), It takes Two to Tango: Is Your Supply Chain a True Business Partner?

Balachandra, R. and Friar, J. H. (1997), Factors for Success in R&D Projects and New Product Innovation: A Contextual Framework; IEEE Transaction on Engineering Management; 44**,** 276 287.

Balasubramanian, S. (2012), A Hierarchical Framework of Barriers to Green Supply Chain Management in the Construction Sector; Journal of Sustainable Development; 5(10), pp.15–2.

Baldauf C, M. and Hubbard, M. (2011), Key issues for the global economy and construction in 2011, Davis Langdon.

Ball, M. (2014), 'Rebuilding Construction: Economic Change in the British Construction Industry', Routledge Publication, USA, p.150-160.

Barratt, M (2004a), "Understanding the meaning of collaboration in a supply chain", Supply Chain Management: An International Journal, Vol.9, No.1, pp. 30-42.

Barratt, M. (2004b), Unveiling Enablers and Inhibitors of Collaborative Planning, the International Journal of Logistics Management, Vol. 15 No 1, pp. 73-90.

Barratt, M. and Oliviera, A. (2001), Exploring the experiences of collaborative planning initiatives, International Journal of Physical Distribution and Logistics Management, Vol.31 (4).

Barrett, K. (2008), 'Defective Construction Work', Blackwell Publishers, UK.

Barton, D (1992), Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development, Strategic Management Journal, 13: 111-126.

Bayus, B. L. (1998), 'An analysis of product lifetimes in a technologically dynamic industry', Management Science Vol.44 (6).

Bell, J. (2005), Is 'Smart Always Sustainable in Building Design and Construction; In: Smart and Sustainable Built Environments. pp. 176-185. J. Young, P.S. Brandon and A.C. Sidwell. NJ, US: Wiley-Blackwell**.**

Bell, K. (2014), 'Achieving Environmental Justice', A Cross-National Analysis', Policy Press, UK.

Bell, M. (2005), Peer Observation Partnerships in Higher Education; Higher Education Research and Development Society of Australasia Inc.Milperra, N. S. W.

Berger, A. N. (1998), 'the economics of small business finance: the roles of private equity and debt markets in the financial growth circle', Journal of Banking and Finance Vol.22.

Bessant, J. and Tidd, J. (2007), Innovation and Entrepreneurship, Chichester, John Wiley & Sons.

Bhamra, T. (2009), Design for Sustainable Living: Turning Values into Actions.

Bhamra, T, Lilley, D, Tang, T (2011), Design for Sustainable Behaviour: Using products to change consumer behaviour, Design Journal, 14(4), pp.427-445.

Bicheno and Matthias Holweg, (2009), The Lean toolbox: the essential guide to Lean transformation - ISBN: 978-0-9541244-5-8 (pbk).

Binggeli, C. (2013), 'Materials for Interior Environments', (Second Edition), John Wiley and Sons Publication, USA.

Birch, A. (2013), 'Economic History of the British Iron and Steel Industry', Routledge Publication, UK.

BIS, (2013a), An economic analysis of the sector, Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210060/bis-13-958-uk-construction-an-economic-analysis-of-sector.pdf.

BIS, (2011), Infrastructure supply chains: barriers and opportunities. London.

BIS, (2013b), Small Business Survey (2012), SME Employers: A report by BMG Research.

Blake, N., Croot, J. and Hastings, J. (2004), Measuring the Competitiveness of the UK Construction.

Blischke, W.R.; Murthy, D. (2000), "Reliability: Modelling, Prediction and Optimization, John Wiley, New York.

Blowfield, M. (2013), 'Business and Sustainability', Oxford University Press Publication, UK, p. 58-86.

Boer, H. and During, W. E (2000), Innovation: What innovation: A comparison between product, process and organisational innovation; International Journal of Technology Management, 22**,** 83-107.

Bonaccorsi, A. and Lipparini, A. (1994), Strategic partnerships in new product development: An Italian case study The Journal of Product Innovation Management Vol.11 (2), BookSurge.

Bosworth, D. L. et al (1993), Research and development in M.C. Fleming (Ed.), Reviews of United Kingdom Statistical Sources Chapman Hall UK.

Bowen, F. E. Cousine, P. D., Lamming, R. C., Faruk, A. C. (2001), Explaining the gap between the theory and practice of green supply, Greener Manage. Int., 35, 41-59.

Brack, D. (2014), 'The Consumer-Country response to illegal logging and the international trade in illegal timber', In Innes, J. L. and Nikolakis, W. Forests and Globalization: Challenges and Opportunities for Sustainable Development, Routledge Publication, UK, p.48-64.

Brannen, J. (1992), Mixing Methods: Qualitative and Quantitative Research; Aldershop: Ashgate Publishing Limited.

Brennan, J. (2013), 'Building Design', In Dimitrijevic, B. Innovations for Sustainable Design and Refurbishment in Scotland, Springer Publication, Switzerland, p.45-66.

Brennan, M. and Cotgrave, A.J. (2013), Development of a measure to assess attitudes towards sustainable development in the built environment: a pilot study.

Brewer, P. and Johnson, L. (2004), Partnering in practice New approaches to PPP delivery*.

Brezet, H., and Hemel, C. van (1997), Ecodesign: A Promising Approach to Sustainable Production and Consumption. Paris: UNEP.

Bribian, I.Z., Capilla, A. and Uson, A.A. (2011), Life cycle assessment of building materials: comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. Building and Environment, 46, 1133-1140.

Brindley, B. and Ritchie, C. (2009), 'Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers', Springer Science and Business Media Publication, UK, p.9-21.

Briscoe, G., and Dainty, A. (2005), Construction supply chain integration: an elusive goal? Supply Chain Management: An International Journal, 10(4), 319–326.

British Environment Agency, (2000), 'State of the Environment of England and Wales: The Land', Stationary Office Publication, UK.

British Parliament House of Commons, (2006), 'Pre-Budget 2005 Tax, Economic Analysis, and Climate Change: Hc 882, Fourth Report of Session 2005-06, Report, Together with Formal Minutes, Oral and Written Evidence', (Environmental Audit Committee), The Stationary Office, UK.

Brundt land Commission (1987), Our Common Future, Oxford University Press.

Bryman, A. (1984), The Debate about Qualitative and Quantitative Research. A Question of Methods or Epistemology; the British Journal of Sociology; 35(1): 75-92.

Building4Change (2012d), Smart walls set to shape sustainable structures.

Burgess, K. et al. (2006), Supply chain management: a structured literature review and implications for future research, International Journal of Operations and Production Management, Vol.26 No.7.

Burn J., Marshall P, Wild M. (1999), Managing knowledge for strategic advantage in the virtual organisation, Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, Louisiana, United States.

Burt, D. N. and Soukup, W. R. (1985), ‘Purchasing’s role in new product development’, Harvard Business Review Vol.63 (5).

Caballero, A.A. et al. (2012), Development of Information Model To Enhance Integration And Coordination In The Construction Projects, Miami, Florida.

Calkins, M. (2009), ‘Materials for Sustainable Sites: A Complete Guide to the Evaluation, Selection, and use of Sustainable Construction Materials’, John Wiley and Sons, USA.

Carter C. and Rogers D.S. (2008), A framework of sustainable supply chain management: moving toward new theory. International Journal of Physical Distribution and Logistics Management 38 (5): 360-387.

Carter, C. and Rogers, D. (2008), ‘a framework of sustainable supply chain management: moving towards new theory International Journal of Physical Distribution and Logistics Management, Vol. 38 (5).

Carter, S.M., and Little, M. (2007), Justifying knowledge, justifying method, taking action: epistemologies, methodologies, and methods in qualitative research; Qual. Health Res. 17, 1316–1328.

Chalmers, D. and Tookey, J. (2013), ‘Prevalence and Nature of Corrupt Practices’, In Dainty, A. and Murray, M, Corporate Social Responsibility in the Construction Industry, Routledge Publication, USA, p.119-140.

Chen, I. J., & Paulraj, A. (2004), Towards a theory of supply chain management: the constructs and measurements. Journal of Operations Management, 22(2), 119–150.

Cheng, J., Law, K. & Bjornsson, H. (2010), Modeling and monitoring of construction supply chains; Advanced Engineering; pp.3–52.

Chew, S. C. (2001), ‘World Ecological Degradation: Accumulation, Urbanization, and Deforestation, 3000 B.C. – A.D. 2000’, Rowman Altermira Publishers, USA, p.131-156.

Chick, A, and Micklethwaite, P. (2011), Design for Sustainable Change: How design and designers can drive the sustainability agenda. AVA Publishing, SA.

Chiesa, V., Coughlan, P., and Voss, C. A. (1996), Development of a Technical Innovation Audit. Journal of Product Innovation Management, 13**,** 105-136.

Cholette, S. and K. Venkat (2009), the Energy and Carbon Intensity of Wine Distribution: A Study of Logistical Options for Delivering Wine to Consumers, Journal of Cleaner Production Issue 17(16).

Christian, H. et al (2012), Creating Collaborative Advantage: Innovation and Knowledge Creation in Regional Economies Gower Publishing, UK.

Christopher, M. (1998), Logistics and Supply Chain Management; Strategies for Reducing Cost and Improving Services, Financial Times Pitman, UK.

Christopher, M. (2013), 'Logistics and Supply Chain Management ePub eBook', Pearson Publication, UK.

CITB, (2010), 'Construction Industry Training Board (CITB-Construction Skills) Annual Reports and Accounts 2009', The Stationary Office Publication, UK, p.17-20.

Clark, K. B. and Fujimoto, T. (1991), Lead time in automobile product development explaining the Japanese advantage Journal of Engineering and Technology Management, Vol. 61 (1).

Coad, A., Cowling, M., Nightingale, P., Pellegrino, G., Savona, M. and Siepel, J. (2014), UK innovation survey: innovative firms and growth. London: Department for Business Innovation & Skills.

Cole, R. J. and Brown, Z. (2009), Human and Automated Intelligence in Comfort Provisioning. PLEA 2009 - 26th Conference on Passive and Low Energy Architecture, Quebec City; Canada. 22-24 June 2009. pp. 18-21.

Conte, E. and Monno, V. (2001), 'Integrating Expert and Common Knowledge for Sustainable Housing Management', in Maiellaro, N. (Ed) Towards Sustainable Building, Kluwer Academic Publishers, USA.

Cooper, M. C. et al. (1990), Supply Chain Management, partnerships, and the shipper-third party relationship, International Journal of Logistics Management Vol.1 , issue -2.

Cooper, R. and Kagioglou, M. et al. (2008), 'Process Management in Design and Construction', John Wiley and Sons Publishers, UK, p.1-10.

Cornick, T. (1996), 'Computer Integrated Building Design', E. and F.N. Spon Publishers, United Kingdom.

Cotgrave, A. and Riley, M. (2013), 'Construction Technology 1: House Construction', Macmillan Publishers, UK, p.81-97.

Coulson, J. (2011), 'Wood in Construction: How to Avoid Costly Mistakes', Wiley-Black Publication, UK.

Coulson, J. (2014), 'Sustainable Use of Wood in Construction', Wiley Publication, UK.

Court, P. et al. (2012), Design of a lean and agile construction system for a large and complex mechanical and electrical project; Building; pp.1–14.

Cousin, D. P. et al (2006), Supply Chain Management Theory and Practice-the emergence of academic discipline; International Journal of Operations and Production Management, Vol.26, Num.7.

Cox, A. and Ireland, P. (2012), Relationship Management Theories and Tools in Project Procurement; In Pryke, S. and Smyth, H. The Management of Complex Projects: A Relationship Approach, Blackwell Publishing, UK, p.267-281.

Crahan, M, E. and Kreiger, J. (2001), 'The Oxford Companion to Politics of the World', Oxford University Press, UK.

Creswell, J. W. (2007), Qualitative inquiry and research method: Choosing among five approaches (2nd. ed.). Thousand Oaks, CA: Sage.

Croom et al (2000), Supply chain management: an analytical framework for critical literate review, European Journal of Purchasing and Supply Management, Vol. 6.

Cumming, B. S. (1998), Innovation Overview and Future Challenges. European Journal of Innovation Management, 1**,** 21-29.

D'Costa, A. (2013), The Global Restructuring of the Steel Industry: Innovations, Institutions and Industrial Change', Routledge Publication, UK.

Dai, M. (2011), ‘Innovative Computing and Information’, Springer Publication, USA, p.81-90.

Darling, P. (2011), ‘SME Mining Engineering Handbook’, (Third Edition), Society for Mining and Metallurgy Publication, USA, p.857-1031.

Davenport, T. H. and Prusak, L. (1998), Working knowledge: How organizations manage what they know, Boston, MA: Harvard Business School Press.

Nightingale, David J. and Cromby, John (1999), Social Constructionist Psychology – a Critical Analysis of Theory and Practice. Open University Press, 236 pages.

Delfmann, W. and De Koster, R. (2005), Supply Chain Management- European Perspectives Copenhagen Business School Press, Denmark.

Dennis, T. and Martin, C. (2001), “An integrated model for the design of agile supply chains”, Journal of Physical Distribution and Logistics Management, Vol.31 Issue - 4.

Denzin, N.K. & Lincoln, Y.S. (2000), “Introduction: The Discipline and Practice of Qualitative Research”. In Handbook of Qualitative Research; (pp. 1-29); Thousand Oaks: Sage.

Department of Business, Innovations and Skills (2013), Supply Chain Analysis into the Construction Industry – A Report for the Construction Industrial Strategy, BIS Research Paper No. 145.

Development Terms (2003), http://www.pdma.org/library/glossary.html.

Development: techniques and perspectives for multi-level analysis’ Edward Elgar Publishing UK.

Dexter, A.L. (1996), Intelligent Buildings: Fact or Fiction? HVAC & R Research, 2 (2); pp 105-106.

Ding, G. K. C. (2012), ‘Environmental Assessment Tool’, In Kuei, C. H. and Madu, C. N, Handbook on Sustainability Management, World Scientific Publication, UK, p.441-472.

DOE, (2003), ‘The business case for sustainable designs in federal facilities’, U.S. Department of Energy, USA.

Domegan, C. and Fleming, D. (2007), Marketing Research in Ireland: Theory and Practice. 3rd edition; Dublin: Gill & MacMillan.

Domone, P. (2010), 'Selection and Sustainable use of Construction Materials', In lllston, J. and Domone, P, Construction Materials: Their Nature and Behaviors, (Fourth Edition), CRC Publication, USA, p.529-550.

Duber-Smith, D. C. (2005), The Green Imperative; Soap, Perfumery, and Cosmetics, 78 (8), pp. 24-26.

Easterby-Smith, M., Thorpe, R., and Lowe, A. (2004), Management Research (Second Edition ed.). London: Sage Publications.

Edwards, B. (2002), Rough Guide to Sustainability; London: RIBA Publications.

Egan, J (1998), "Rethinking Construction: Report of the Construction Task Force", London: DETR.

Egan, J. (2002), "Accelerating Change", Published by Rethinking Construction, c/o Construction Industry Council.

Egbu, C.O., Anumba, C.J. and Carrillo, P.M. (2005), Knowledge Management in Construction C. O. E. and P. M. C. Chimay J. Anumba, ed., Blackwell Publishing Ltd.

Eid, M. (2013), 'How can Sustainable Development Redefine Project Management Processes?' In Gilbert, S, Sustainability Integration for Effective Project Management, IGI Global Publication, USA, p.76-94.

Eisenhardt, K. M. and Tabrizi, B. N. (1995), Accelerating adaptive processes: Product innovation in the computer industry, Administrative Science Quarterly Vol.40 (1).

El-Gamal, M. et al. (2010), 'Sulfur Concrete for the Construction Industry: A Sustainable Development Approach', J. Ross Publishing, USA, p.18-21.

Elkington, J. (1998), 'Cannibals with forks: The Triple Bottom Line of the 21st Century', New Society Publishers, UK.

Elkington, J. (2004), Enter the triple bottom line In: Henriques, A. and Richardson, J. (Eds.) The Triple Bottom Line: Does It All Add up? Earth scan, UK.

Engelman, R. (2013), 'Beyond Sustainability', In the Worldwatch Institute, State of the World 2013: Is Sustainability still Possible? Worldwatch Institute Publication, USA.

Enkel, E., Bell, J. and Hogenkamp, H. (2011), Open Innovation Maturity Framework. International Journal of Innovation Management, 15**,** 1161-1189.

Eppler, M.J., Seifried, P.M., and Ropnack, A. (1999), Improving knowledge intensive processes through an enterprise knowledge medium, Proceedings of the ACM SIGCPR Conference on Computer Personnel Research, 1999, pp. 222–230.

Ettlie, J. E. (2006), Managing Innovation: New Technology, New Products, and New Service in a Global Economy, Burlington, Elsevier Butterworth-Heinemann.

Evangelinos, E, and Zacharopoulos, E. (2013), 'Sustainable Design, Construction and Operation', In Santamouris, M, Environmental Design of Urban Buildings: An Integrated Approach, Earthscan Publishers, UK, p.63-74.

Farmer, D. (1972), The impacts of supply markets on corporate planning, Long Range Planning, Vol.5 Num. 1, pp. 10 - 15

Fellows, R. and Liu, A. (2008), Research methods for construction, 3rd ed, Chichester, Wiley.

Fisher, M.L. (1997), What is The Right Supply Chain for Your Product? A simple framework can help you Figure out the answer, Harvard Business Review Vol.75 No.2.

Flammini, A. and Sims, R.E. H. (2014), 'Energy-smart Food-technologies, Practices and Policies', In Chen, G. and Bundschuh, J, Sustainable Energy solution in Agriculture, CRC Publication, UK, p.123-162.

Fleischmann, B., Meyr, H. and Wagner, M. (2002), "Advanced Planning," in Stadler, H. and Kilger, C., (Eds.), Supply Chain Management and Advanced Planning: Concepts, Methods, Software and Case Studies, Springer, Berlin, pp. 71-96.

Flyvbjerg, B., Bruzelius, N. and Rothengatter, W. (2003). Megaprojects and Risk: An Anatomy of Ambition. Cambridge: Cambridge University Press.

Forgues D Koskela L, Lejeune A (2009). Information Technology as Boundary Object for Transformational Learning. J. Inf. Technol. Construct. (ITcon), 14: p 48 - 58.

Franzoni, E. (2011), Materials selection for green buildings: which tools for engineers and architects? Procedia Engineering, 21, 883-890.

Chiesa, V. and Frattini, F. (2007), Exploring the differences in performance measurement between research and development: evidence from a multiple case study, R&D Management, Vol. 37 No. 4, pp.

Frazier, G.L. (1999), Organizing and managing channels of distribution, Journal of the Academy of Marketing Science, Vol.27 Iss.2

Freed, C. E. (2011), 'Green Buildings and Remodelling for Dummies', John Wiley and Sons Publication, USA, p.141-175.

Freeman, C. (1994), Critical Survey: The Economics of Technical Change. Cambridge Journal of Economics, 18**,** 463-514.

Teuteberg, F. and Wittstruck, D. (2010), A Systematic Review of Sustainable Supply Chain Management Research –What is there and what is missing? p 1001-1015.

Fuller, B. (2005), 'Cultures of the World: Great Britain', Marshall Cavendish Publication, China, p.6-10.

Fumerton, **R**. (**2004**)**,** Epistemic probability**,** Philosophical Issues v14 **(1),** pp149**-**164

Gallent, N. and Bevan, M. et al. (2010), 'The Rural Housing Question', The Policy Press, UK, p.208-237.

Garcia, M.A. (2005), Challenges of the construction sector in the global economy and the knowledge society. International J. Strat. Property Manage., 9: 65 – 77.

Garcia, P.J.M. (2005), 'Global Structural Wood Product Sector', In Hoen, H. F. and Innes, J. L. et al. Forestry and Environmental Change: Socioeconomic and Political Dimensions, (Report No.5), CABI Publishing, UK, p.165-171.

Gavin, D. A (1988), Digital Equipment Corporation: The endpoint model. Case Study 9-688-059, Harvard Business School USA.

Gechev, R. (2005), 'Sustainable Development: Economic Aspects', University of Indianapolis Press, USA.

General Electric, Stone Yamashita Partners (2005), An Adventure inside the World's Largest Innovation Lab // GE Inc.; Stone Yamashita Partners, Inc.

Gerwin, D. and Barrowman, N. J. (2002), 'An evaluation of research on integrated product development', Management Science Vol.48 (7).

Gingembre, L. (2013), 'Haiti: Lessons Learned and Way forward in Natural Resource Management Projects', In Lonergan, S. and Jensen, D. Assessing and Restoring Natural Resources in Post-Conflict Peace building, Earthscan Publishers, USA, p.241-267.

Globio, E. (2012), Thesis writing;

http://www.slideshare.net/erwin_globio/thesiswriting.

Glossary of New Product Development Terms (2003), http://www.pdma.org/library/glossary.html.

Goldman Sachs Investment Research (2000), Internet: B2B e-Commerce, USA.

Gonzalez M, Arrunada B, Fernandez A (1998), Regulation as a Cause of Firm Fragmentation: The Case of the Spanish Construction Industry. Int. Rev. Law and Econ., 18: 433-450.

Goodridge, P., Haskel, J. and Wallis, G. (2012), UK Innovation Index: Productivity and Growth in UK Industries; Nesta Working Paper; London: Nesta.

Great Britain National Audit Office, (2007), 'Building for the future: sustainable construction and refurbishment on the government estate', National Audit Office, UK.

Green, S. D (2011), 'Making Sense of Construction Improvement', Wiley Blackwell Publication, UK, p.345-56.

Greenwood, D. and Bouazza, T. et al. (2015), 'The Use of Building Information Modelling (BIM) in Managing Knowledge in Construction Project Delivery: A Conceptual Model', In Laing, R. and Mahdjoubi, L. Building Information Modelling (BIM) in Design, Construction and Operations, WIT Press, UK p.107-118.

Guan, J. C., YAM, R. C. M., MOK, C. K. & MA, N. (2006), A study of the relationship between competitiveness and technological innovation capability based on DEA models. European Journal of Operational Research, 170**,** 971-986.

Guertin, M. (2011), 'Green Applications for Residential Construction', Cengage Learning Publication, USA, p.14-30.

Gunasekaran, A, and Ngai, E.W. (2004), Information systems in supply chain integration and management; European Journal of Operational Research, 159(2), pp.269–295.

Guthrie, P. M. and Runguphan, T. (2009), 'Investigation on the use of burnt colliery spoil as aggregate in low to normal strength concrete', In Kew, H. Y. and Limbachiya, M. C, Excellence in Concrete Construction through Innovation: Proceedings of the Conference held at the Kingston University, United Kingdom, CRC Publication, UK, p.559-564.

Reichl, H., Griese H., Potter H. (2004), Electronics Goes Green 2004+, Driving forces for future electronics; Sept. 6-8, Berlin, Germany.

Haggett, P. (2002), 'Encyclopaedia of World Geography: the British Isles ', Vol. 24, Marshall Cavendish Publishers, USA, p.967-977.

Halliday, S. (2008), 'Sustainable Construction', Routledge Publication, UK.

Halliwell, S. (2003), 'Polymers in Building and Construction', iSmithers Rapra Publishing, UK, p.40-52.

Hamel, G. (2006), The Why, What, and How of Management Innovation. Harvard Business Review, 82**,** 72-84.

Hansman, R. (2010), Sustainability learning: An introduction to the concept and its motivational aspects. Sustainability, 2, 2873-2897.

Harland C.M. (1996), Supply Chain Management: relationships, chains and networks. British Journal of Management 7(1), p. 63-80.

Harland, C. (1996), Supply Chain Management: Relationships, chains and networks, British Journal of Management Vol.7 Iss -1.

Harland, C.M. (1996), Supply chain management: relationships, chains and networks. British Journal of Management Issue 7(1).

Harmancioglu, N. (2007), Your new product development (NPD) is only as good as your process: an exploratory analysis of new NPD process design and implementation, School of Business Administration, University of Dayton, R&D Management, Volume 37, Issue 5, Page 399-424, Nov 2007.

Harper, G.D.J. (2012), Intelligent buildings: sustainable or just lazy? Green Building Magazine, 22 (2), pp.48-53.

Harrison, D. J. et al. (2005), 'Sustainable River Mining in of Aggregates in Developing Countries', In Marker, B, Sustainable Minerals Operations in Developing World, Geological Society of London, UK, p.35-45.

Harrison, T. P. et al (2003), The Practice of Supply Chain Management: where Theory and Application Converge, Springer Science and Business Media, USA.

Heikkila, J. (2002), From supply to demand chain management: Efficiency and customer satisfaction, Journal of Operations Management Vol.20 Iss – 6.

Henning, E., Van Rensburg, W. and Smit, B. (2004), Finding your way in qualitative research. Pretoria: Van Schaik.

Heredia, S. and Manuel, J. (2014), 'The Environmental Dimension of Sustainable Development: The Heritage Dimension of the Climate System and its Protection for the Benefit of Mankind', In Negri, S. and Fitzmaurice, M, Environmental Protection and Sustainable Development from Rio to Rio+20, Martinus Nijhoff Publishers, The Netherlands, p.65-79.

Hermitage, A. and Edward, O. (2007), 'MTV England', John Wiley and Sons Publishers, UK, p.4-10.

Higgon, D. and Loosemore, M. (2015), 'Social Enterprise in the Construction Industry: Building Better Communities', Routledge Publication, USA, p.10-20.

Higgs, C. and Ashworth, A. et al. (2013), Willi's Practice and Procedures for the Quantity Surveyor, (13th Edition), John Wiley and Sons Publishers, UK.

Hinchey (2008), Action Research Primer (New York: Peter Lang).

HM Government (2015), Strengthening UK manufacturing supply chains, an action plan for government and industry.

H M Treasury, (2012), Infrastructure Cost Review: Annual Report, London. Available at: http://www.hm-treasury.gov.uk/d/iuk_cost_review_implementation_plan.pdf.

Hogwood, P. (2013), 'The UK's devolved authorities and the European Sustainability discuss: between identity and actor hierarchy', In Hoerber, T. C. and Barnes, P. M. Sustainable Development and Governance in Europe: the Evolution of the discourse on Sustainability, Routledge Publication, USA, p.177-189.

Hope, R. (2012), A Vision for the Future of Construction: Supply Chain Management and Integration.

House of Commons Environmental Audit Committee, (2009), 'Reducing Green House Gas Emissions from Deforestation: No Hope without Forests, Stationary Office Publication, UK, p.7-23.

House of Commons Environmental Audit Committee (2011), Embedding Sustainable Development across Government, After the Secretary of State's Announcement on the Future of the Sustainable Development Commission, Stationary Office Publication, UK, p.45-60.

House of Lords (2011), Science and technology committee: first report; public procurement as a tool to stimulate innovation; House of Lords, London; March 2011.

Hsu, C. W. and Hu, A. H. (2007), Green supply chain management in the electronic industry. International Journal of Environ. Sci. Tec., 5(2), 205-216.

Hsu, Y.H. and Fang, W. (2009), Intellectual capital and new product development performance: The mediating role of organizational learning capability, Technological Forecasting and Social Change, Vol. 76, No. 5, pp. 664-677.

Huelman, P. H. and Hendricks, L. T. (2005), 'Design Considerations for exterior envelops of buildings in cold climate regions beyond 2000', In Happold, E and Allen, W.

A. et al. A Global Strategy for Housing in the Third Millennium, Taylor and Francis Publishers, USA, p.42-54.

Huggett, R. (2013), 'Fundamentals of Geomorphology', Routledge Publication, USA.

Hughes, W., Hillebrandt, P. M., Greenwood, D. G. and Kwawu, W. E. K. (2002), Developing a system for assessing the costs associated with different procurement routes in the construction industry Management.

Hulse, J.H. (2007), 'Sustainable Development at Risk': ignoring the past, Cambridge University Press, New Delhi.

Hutchinson, C. (2014), 'Building to Last the Challenge for Business Leaders', Routledge Publication, USA, p.7-15 intensive processes through an enterprise knowledge medium, Proceedings of the ACM SIGCPR Conference on Computer Personnel Research, New Orleans, Louisiana, United States of America pp. 222-230.

International Journal of Logistics Management, Vol.15, No.1, pp. 73-90. John Wiley, New York.

Janda, B. (2011), Buildings don't use energy: people do. Architectural Science Review, 54, pp.15-22, Earthscan.

Johnson, D. (2010), 'Limestone Industries of the Yorkshire Dales', Amberley Publication, UK.

Jones, M. (2013), 'Supply Chain Management in Construction', In Fewings, P. Construction Project Management, Routledge Publication, USA, p.426-469.

Jorde, T. and Teece, D. (1989), Cooperation and competition: striking the right balance, California Management Review Spring, Vol.31 (3).

Jorgensen, B. & Emmitt, S. (2008), Lost in transition: the transfer of lean manufacturing to construction. Engineering, Construction and Architectural Management, 15(4), pp.383–398.

Kagioglou, M. and Cooper, R. (2012), Re-engineering the UK construction industry: the process protocol, Salford. Available at: http://processprotocol.com/pdf/cpr99.pdf.

Kanter, R. M. (1994), Collaborative advantage: the art of alliances. Harvard Business Review July-August.

Keeley, L., Pikkel, R., Quinn, B. and Walters, H. (2013), Ten Types of Innovation: The discipline of building breakthroughs, Hoboken, John Wiley and Sons.

Kelley T., Littman J. (2005), The Ten Faces of Innovation: IDEO's Strategies for Defeating the Devil's Advocate and Driving Creativity throughout Your Organization // New York: Currency.

Kelvin, B. et al (2006), Supply Chain Management: a structured literature review and implications for future research in Supply Chain Management Theory and Practice-the emergence of academic discipline? International Journal of Operations and Production Management, Vol.26, Num.7.

Khalfan, M. M. A. and McDermott, P. (2007), Integrated Supply Chain – An Example from the UK Construction Industry. In The construction and building research conference of the Royal Institution of Chartered Surveyors (p. 13). Atlanta: RICS, London.

Kibert, C. J. (2012), 'Sustainable Construction: Green Building Design and Delivery', John Wiley and Sons Publishers, USA.

Kilger, C., Stadtler, H. (2000), Supply Chain Management and Advanced Planning, Concepts, Models, Software and Case Studies. Springer, Heidelberg, 2000.

Kim W.C., Mauborgne R. (2005), Blue Ocean Strategy: How to Create Uncontested Market Space and Make Competition Irrelevant // Harvard Business Press.

Kim, L. and Nelson, R. R. (2000), Technology, learning, and innovation: Experiences of newly industrializing economies, Cambridge, UK: Cambridge University Press.

Kivrak, S. & Arslan, G. (2008), Capturing knowledge in construction projects: Knowledge platform for contractors. Journal of Management in, (April), pp.87–96. Available at: http://ascelibrary.org/doi/abs/10.1061/(ASCE)0742-597X(2008)24:2(87)

Klepeis, N. E., Nelson, W. C., Ott, W. R., Robinson, J. P., Tsang, A. M. and Switzer, P. (2001), The National Human Activity Pattern Survey (NHAPS): A resource for assessing exposure to environmental pollutants. Journal of Exposure Analysis and Environmental Epidemiology, 11(3), pp. 231-252.

Klunster, J. H. and Salingaros, N. A. (2001), 'The end of Tall Buildings', Planetizen, the Planning and Development Network.

Kocoglu, I. et al. (2011), The effect of supply chain integration on information sharing: Enhancing the supply chain performance; Procedia - Social and Behavioral Sciences, 24, pp.1630–1649.

Kothari, C. R. (2004), Research Methodology, Methods and Techniques, 2nd Edn, New Age International (P) Ltd Publishers, New Delhi, India.

Kotsemir, M N. and Abroskin, A. S. (2013), Innovation Concepts and typology - An evolutionary Discussion, working paper, WP BRP 05/STI/2013.

Kraljic, P. (1983), Purchasing Must Become Supply Management Harvard Business Review, September/October.

Kroner, W. M. (1997), An intelligent and responsive architecture', Automation in Construction, **vol. 6, pp. 381-393**, 1997.

Kwan, A.S.K. and Sansom, M. et al. (2003), 'A Life-Cycle Energy Model of the UK Steel Construction Sector', In Bontempi, F, Structural and Construction Conference, CRC Publishers, The Netherlands, p.309-314..

Laing, R. (2013), 'Towards More Sustainable Built Environments', In Dimitrijevic, B. Innovations for Sustainable Design and Refurbishment in Scotland, Springer Publication, Switzerland, p.11-18.

Lall, S., Albaladejo, M. & Zhang, J. (2004), Mapping fragmentation: electronics and automobiles in East Asia and Latin America; Oxford Development Studies, (115), pp.1–30.

Lambert, D. M. and Cooper, M. C. (2000), Issues in Supply Chain Management; Industrial Marketing Management, 29(1), pp.65–83.

Lambert, D. M. et al (1998), supply Chain Management Implementation Issues and Research Opportunities, The International Journal of Logistics Management Vol.11, Iss - 1.

Lamming, R.C. (1993), Beyond Partnership: Strategies for Innovation and Lean Supply" Prentice-Hall Press, UK

Langford D, Male S (2001), Strategic management in construction (2nd ed.); London Blackwell Science.

Law, B. (2010), 'Round Wood Timber Framing: Building Naturally using Local Resources', Permanent Publications, UK.

Layard, (2012), 'The Legal Framework of Sustainable Development', In Layard, A. and Batty, S. et al. Planning for a Sustainable Future, Routledge Publication, USA, p.33-52 learning capability, New York: Oxford University Press.

Lee and Weiss (1997), "SFF Processes," JTEC/WTEC Panel Report on Rapid Prototyping in Europe and Japan; March 1997.

Lee, H.L. (1993), Designing for Supply Chain Management: Concepts and Examples, Kluwer Academic Publishers, USA.

Lee, H.L. (2004), The Triple-A Supply Chain, Harvard Business Review Vol.82 No.10.

Leong, T. W. (2015), 'Principles of Supply Chain Management: A Balanced Approach, Purchasing, Logistics and Operations', Cengage Learning Publication, USA.

Lewis, M. and Lloyd-Jones, R. (2014), 'British Industrial Capitalism Since the industrial Revolution', Routledge Publication, USA, p.62-78.

Lim, M, (2014), *Rock Coast Geomorphology: A Global Synthesis*, The rock coast of the British Isles: cliffs, Geological Society, London, Memoirs, eds Kennedy D. M., Stephenson W. J., Naylor L, **40**, pp 19–38.

Lipsey, R. and Chrystal, A. (2015), 'Economics', (Thirteenth Edition), Oxford University Press, UK, p.639-670.

London, K., & Kenley, R. (2001), An industrial organization economic supply chain approach for the construction industry: a review. Construction Management and Economics, 19(8), 777–788.

Lynagh, C. (2011), Construction industry facing "huge problems" Business News, Business - Belfasttelegraph.co.uk.

Lynagh, C. (2011), Construction industry facing "huge problems" Business News, Business - Belfasttelegraph.co.uk.

MacGregor, I. (2012), 'A Narrative: The Political Economy of Privatization in Britain', In Zeckhauser, R. and Macavoy, P.W. et al., Privatization and State Owned Enterprises: Lessons from the United States, Great Britain and Canada, Springer Science and Business Media Publication, UK, p.263-271..

Mahoney, J. and Rueschemeyer, D. (2003), 'Comparative Historical Analysis: achievement and agendas', in Comparative Historical Analysis in the Social Sciences, Cambridge: Cambridge University Press, pp. 3–38.

Malina, M. (2013), 'Delivering Sustainable Buildings: An Insider's View', Wiley-Blackwell Publication, UK.

Maps of World, (2015), 'UK Maps: About the UK', [Available at] http://www.mapsofworld.com/united-kingdom/

Martin, S. et al. (2014), 'Reflections on ESD in UK Schools', In Mathar, R. and Jucker, R. Schooling for Sustainable Development in Europe: Concepts, Policies and Educational Experiences at the End of the UN Decade of Education for Sustainable Development', Springer Publication, Switzerland, p.335-360.

Marzilli, A. and Ruschmann, P. (2009), 'Environmental Regulations and Global Warming', Info base Publishing, USA, p.90-97.

Masood, S (2005), Intelligent rapid prototyping with fused deposition modelling, Rapid Prototyping Journal, (1996), Volume: 2. Issue: 1, Page: 24-33,

Masters, N. (2001), 'Sustainable Use of New and Recycled Materials in Coastal and Fluvial Construction: A Guidance Manual', Thomas Telford Publication, UK.

Masters, T and Maric, V. et al. (2010), London, Con Pianta, Ediz, Inglese, Lonely Planet Publishers, UK, p.15-29.

Mather, J. and Cornick, T. (1999), 'Construction Project Teams: Making the work profitably', Thomas Telford Publishing UK.

McLeod, F. and Cherrett, T. (2013), 'Reverse Logistics for Sustainable Waste Management Processes', In Management Association and Information Resources, Sustainable Practices: Concepts, Methodologies, Tools, and Applications, IGI Global Publishers, USA, p.1505-1518.

Meyr, H., Wagner, M. and Rohde, J. (2005), "Structure of Advanced Planning Systems", in Stadtler and Kilger (eds.) Supply Chain Management and Advanced Planning – Concepts, Models, Software and Case Studies, Springer, Berlin, 109-115.

Miles, M.B and Huberman, A.M. (1994), Qualitative data analysis: an expanded sourcebook (2nd ed.). London: Sage.

Miles, N., Wilkinson, C., Edler, J., Bleda, M., Simmonds, P. and Clark, J. (2009), The Wider Conditions for Innovation in the UK: How the UK compares to leading innovation nations; National Endowment for Science, Technology and the Arts.

Miller, A. and Kenneth, Ip. (2013), 'Sustainable Construction Materials', In Sayigh, A, Sustainability, Energy and Architecture: Case Studies in Realizing Green Buildings, Academy Publication, USA, p.79-91.

Modi, S. B. (2006), Role of supply Chain Capabilities in Organizational Innovation Efforts ProQuest Information USA.

Moore G.A. (2005), Dealing with Darwin: How Great Companies Innovate at Every Phase of Their Evolution // New York: Penguin Group.

Moore, D. and Ochieng, E. et al., (2013), 'Management of Global Construction Projects', Palgrave Macmillan Publishers, UK, p.266-290

Moore, D. and Price, A. et al. (2013), 'Management of Global Construction Projects', Palgrave Macmillan Publishers, UK, p.180-195.

Morana, J. (2013), 'Sustainable Supply Chain Management', Wiley Press, UK.

Moulaert, F. and Ancien, D. (2013), London between Global narcissism and National Responsibility: the Globalization of a Capital City at the Expense of its Nation, In Novy, A. and Martinelli, F. et al. Urban and Regional Development Trajectories in Contemporary Capitalism, Routledge Publishers, USA, p.61-85.

Moyaux T. et al (2007), Supply chain management and multi-agent systems: An Overview.

Myers, D. (2013), Construction Economics: A New Approach, Routledge Publication, UK, p.203-217 and 271.

Myers, M. D. (2009), 'Qualitative Research in Business and Management', Sage, London.

Nadin, V. and Colomb, C. et al. (2010), European Spatial Planning and Territorial Cooperation, Routledge Publication, USA, p.160-176.

Naoum S. G. (1998), Dissertation research and writing for construction students, Elsevier.

National Academy of Science, (2002), Evolutionary and Revolutionary Technologies for Mining, National Academy Press, USA.

National Audit Office (2007), Building for the Future: Sustainable Construction and Refurbishment on the Government Estate, the Stationery Office, UK.

National Audit Office (2015), A short guide to environmental protection and sustainable development, the Stationery Office, UK.

NESTA, (2008b), Total Innovation: Why Harnessing the Hidden Innovation in High-technology Sector is Crucial to Retaining the UK's Innovative Edge, NESTA.

Nonaka, I. (2001), A dynamic theory of organizational knowledge creation. Organization Science 5(1), 14-37.

Nonaka, I., Toyama, R., Nagata, A. (2000), "A firm as a knowledge-creating entity: a new perspective on the theory of the firm", Industrial and Corporate Change, Vol. 9 No.1, pp.1 - 20.

Norton, P. (2013), ‘Parliament in British Politics’, (Second Edition), Palgrave Macmillan Publishers, UK, p.167-180.

Ochieng, E., Price, A., Moore, D. (2013), Management of Global Construction Projects.

O’neill, M. (2014), ‘A Kingdom United’, In O’neill, M. Devolution and British Politics, Routledge Publishers, USA, p.1-20.

OECD, (2003), ‘Environmentally Sustainable Buildings: Challenges and Policies’, OECD Publication Service, France, p.3-12.

OECD, (2005), Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. 3rd Edition ed.: OECD and Eurostat.

OECD, (2013), ‘Global Forum on Transparency and Exchange of Information for Tax Purposes Peers reviews: United Kingdom 2013 Combined Phase 1 + Phase 2’, OECD Publishing, France, p.11-20.

Office of National Statistics, (2015), Population Estimates for the UK; England and Wales, Scotland and Northern Ireland Mid-2014.

Ofori, G. (1990), The Construction Industry: Aspects of its Economics and Management, Singapore University Press, Singapore.

Oliver, R. K. and M.D. Webber (1992), Supply Chain Management: Logistics catches up with strategy In M. Christopher (ed.), Logistics: the strategic issues, Chapman and Hall, UK.

ONS, (2014), Statistical Bulletin Output in the Construction Industry, November 2013.

Onwuegbuzie, A. J., & Johnson, R. B. (2004), Mixed method and mixed model research. In R. B. Johnson & L. B. Christensen, Educational research: Quantitative, qualitative, and mixed approaches (pp. 408-431). Needham Heights, MA: Allyn & Bacon.

Orange, G., Burke, A. and Boam, J. (1994), Organisational Learning in the UK Construction Industry: A Knowledge Management Approach, Leeds.

Orange, G., Burke, A. & Boam, J. (1994), Organisational Learning in the UK Construction Industry: A Knowledge Management Approach, Leeds.

Ottman, J. (2004), Green marketing: Opportunity for innovation. Charleston. SC,

Owen, A. (2011), Decisions, decisions: How do real people choose green measures and technology? Green Building Magazine; Llandysul, Green Building Press; Spring 2011, 20(4), pp. 22-24.

Owen, R. and Koskela, L. (2006), Is agile project management applicable to construction? In for Lean Construction; pp. 51–66.

Parker, D. and Dickson, M. (2014), 'Sustainable Timber Design', Routledge Publication, USA.

Parliament House of Commons, (2008), Innovations, Universities, Science and Skills Committee, 'Renewable Electricity – Generation Technologies: Oral and Written Evidence', The Stationary Office Publication, UK, p.336-355.

Parliament House of Commons, (2010), 'Teesside cast Products: Second Report of Session-2009-10', The Stationery Office, UK.

Parliament House of Commons, (2010), Energy and Climate Change Committee, 'Low Carbon Technologies in a Green Economy', (Fourth Report of Session 2009-10), Vol. 1; The Stationary Office Publication, UK, p.5-30.

Paulraj, A. and Chen, I.J (2004), Towards a theory of supply chain management: the constructs and measurements, Journal of Operations Management, Vol. 22, No.2.

Perera, S. and Ashworth, A, (2015), 'Cost Studies of Buildings', (Sixth Edition), Routledge Publication, USA, p.32-47 perspective on the theory of the firm", Industrial and Corporate Change, Vol. 9 No.1.

Pero, M., Moretto A, Bottani E., Bigliardi B. (2017), Environmental Collaboration for Sustainability in the Construction Industry: An Exploratory Study in Italy; Department of Management, Economics, and Industrial Engineering, Piazza Leonardo.

Peters, M. and Fudge, S. (2013), The National Dialogue on Behaviour Change in the UK Climate Change Policy: Some Observations on Responsibility, Agency and Political Dimensions, In Lehman, S. and Crocker, R, Motivating Change: Sustainable Design and Behavior in the Built Environment, Routledge Publication, UK, p.71-91.

Pheng, L.S. and Fang, T.H, (2005), Modern-day lean construction principles: Some questions on their origin and similarities with Sun Tzu's Art of War; Management Decision, 43(4), pp.523–541.

Plank, R. (2013), 'Steel', In Cather, D. and Doran, B, Construction Materials Reference Book, (Second Edition), Routledge Publication, UK, p.83-96.

Poirier, C. C. (2005), Using Models to Improve the Supply Chain, St. Lucie Press, USA.

Polit, D.F. and Beck, C.T. (2010), International Journal of Nursing Studies 47 1451–1458.

Pope, R. (2013), 'The British Economy Since 1914: A Study in Decline', Routledge Publishers, USA.

Preston, P. W. (2014), Britain after Empire: Constructing a Post-War Political-Cultural Project, p.180-210 process: an exploratory analysis of new NPD process design and implementation, School of Product Development & Management Association (PDMA, 2003).

Ragatz, G. L. et al, (1997), Success factors for integrating suppliers into new product development, The Journal of Product innovation Management Vol.14 (3).

Rahimnia, F. & Moghadasian, M. (2010), Supply chain legality in professional services: how to apply decoupling point concept in healthcare delivery system. Supply Chain Management: An International Journal, 15(1), pp.80–91.

Rankin, W. J. (2011), 'Minerals, Metals and Sustainability: Meeting Future Material Needs', CSIRO Publishing, Australia, p.89-95.

Rashkin, M. D. (2007), 'Practical Guide to Research and Development: Tax Incentives', (2nd Ed) CCH Group Publishing, USA.

Reed, B. and 7group (2011), 'The Integrative Design guide to Green Building: Redefining the Practice of Sustainability', John Wiley and Sons Publication, UK.

Refaee, M, and Altan, H. (2014), An Evaluation of Indoor Environment in Deprived Community Housing In Yorkshire and the Humber Region of England, UK, In Kucuk, H. and Dincer, I. et al., Progress in Sustainable Energy Technologies Vol. 11: Creating Sustainable Development, Springer Publication, UK, p.123-134.

Retik, A. et al. (2012), The Organisation and Management of Construction: Shaping Theory and Practice, (Volume One), Routledge Publishers, UK.

Rezgui, Y. et al. (2011), Past, present and future of information and knowledge sharing in the construction industry: Towards semantic service-based e-construction? Computer-Aided Design, 43(5), pp.502–515.

Ribeiro, F. L., & Fernandes, M. T. (2010), Exploring agile methods in construction small and medium enterprises: a case study. Journal of Enterprise Information Management, 23(2), 161–180.

Rich, N. and Holweg, M. (2010), Developing and Maintaining Supply Chain Relationship, In Bidgoli, H.**;** The Handbook of Technology Management: Supply Chain Management, Marketing and Advertising, and Global Management', (Volume 2), John Wiley and Sons Publishers, UK, p.28-39.

Rich, N. et al (1997), Supply chain management and time-based competition: the role of the supplier association, International Journal of Physical Distribution and Logistics Management, Vol.27.

Richardson, A. (2013), Re-Use of by products and Materials, in Richardson, A. Reuse of Materials and By products in Construction: Waste Minimization and Recycling, Springer Publishers, UK, p.1-5.

Roberts, K. (2011), Class in Contemporary Britain, Palgrave Macmillan Publishers, UK, p.48-79.

Rojas, E. M. (2008), Construction Productivity: A practical guide to building and electrical contractors, J. Ross Publishing, USA.

Ross, A. (2013), Sustainable Development Law in the UK: From Rhetoric to Reality, Routledge Publication, USA.

Royal Commission on Environmental Pollution, (2007), The Urban Environment, The Stationery Office, UK, p.130-150.

Rusk, B. and Bhattacharjee, B. et al. (2012), Sustainability Education in the United States: An analysis of the Curricula Used in Construction Programs, in Hermreck, C. and Chong, W.K.O, Integrating Sustainability Practices in the Construction Industry: proceedings of the 2011 international conference on Sustainable Design and Construction, American Society of Civil Engineers Publication, USA.

Sacks, R., Dave, B., Koskela, L.J. and Owen, R.L., (2009), Analysis framework for the interaction between lean construction and building information modelling, in: 17th Annual Conference of the International Group for Lean Construction, 15th-17th July 2009, National Pingtung University of Science and Technology, LCI-Taiwan and LCI-Asia, The Grand Hotel, Taipei, Taiwan.

Saini, M. (2015), A framework for transferring and sharing knowledge in construction supply chains within lean and agile processes (Doctoral Thesis), Salford, UK).

Salunke, S., Weerawardena, J. and McColl-Kennedy, J. R. (2011), Towards a model of dynamic capabilities in innovation-based competitive strategy: Insights from project-oriented service firms Industrial Marketing Management, 40**,** 1251-1263.

Samuels, H. and Webley, L. (2015), 'Complete Public Law: Text, Cases, and Materials', Oxford University Press, UK, p. 292-331.

Sanderson, J. and Cox, A. (2008), The challenges of supply strategy selection in a project environment: evidence from UK naval shipbuilding. Supply Chain Management: An International Journal, 13(1), pp.16–25.

Sands, P. (2000), Environmental protection in the twenty-first century: Sustainable development and international law in R. L. Revesz et al. (Eds) Environmental law, the economy and sustainable development: the United States, the European Union and the international community Cambridge University Press, UK.

Sands, R. (2013), 'A History of Human Interaction with Forests', In Sands, R, Forestry in a Global Context, (Second Edition), UK, p.1-34

Sarsby, R. W. and Serridge, C. J. (2011), 'Assessment of the use of Recycled aggregates in vibro-stone column ground Improvement Techniques', In Meggyes, T. and Sarsby, R, Construction for a Sustainable Environment, CRC Publication, USA, p.75-90.

Saunders, M. Lewis, P. and Thornhill, A. (2007), Research Methods for Business Students, 4th ed. London: Prentice Hall..

Sawe, E. N. (2011), 'Sustainable Charcoal and Firewood Production and Use in Africa', In Rutz, D. and Janssen, R. (2011), Bioenergy for Sustainable Development in Africa, Springer Publication, Germany, p.75-80.

Schwandt, T. A. (2001), Dictionary of Qualitative Inquiry, Second Edition, London: Sage Publications Science 5(1), 14-37.

SCOR, (2008), Supply chain operations reference model, SCOR; Available at: http://www.leanportal.sk/Files/Modely/SCOR.pdf

Scotland, James (2012), 'Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms; *English Language Teaching;* Vol. 5, No. 9; pp. 9-16.

Sen, F. K. and Egelhoff, W. G. (2000), Innovative Capabilities of a Firm and the Use of Technical Alliances; IEEE Transaction on Engineering Management, 47**,** 174-183.

Setar, L. (2013), Top Sectors for Regulatory Change; IbisWorld.

Seuring S., Muller M. (2008), From a literature review to a conceptual framework for sustainable supply chain management / Journal of Cleaner Production, 16, 1699–1710.

Sexton, M (2003), A supple approach to exposing and challenging assumptions and PhD path dependencies in research, Key note speech of the 3rd International Postgraduate Research Conference, Lisbon.

Shapiro, F.J. (2009), Modelling the supply chain (2nd Ed.) Centage, USA.

Shiers, D. and Keeping, M. (2009), Sustainable Property Development: A Guide to Real Estate and the Environment, John Wiley and Sons Publication, UK, p.142-156.

Short, A. (2010), ** Glass Buildings Are Set to Become Pariahs;** Building Design; 1906, p.1.

Shukla, and Shukla, et al. (2015), 'Achieving Energy Sustainability through Green Building Approach', In Sharma, A. and Kar, K. Energy Sustainability through Green Energy, Springer Publication, India, p.147-162.

Siddiqui, S. A. (2011), 'Comprehensive Economics XI', Laxmi Publication, India, p.375-396.

Slomp, H. (2011), 'Europe: A political Profile; An American Companion to European Politics', ABC-CLIO Publishers, USA, p.330-340.

Smith, W. (2002), 'Developing Indicators of Sustainability', in Cocklin, C. et al 'The Sustainability of Rural Systems Geographical Interpretations', Kluwer Academic Publishers, USA.

Stallworthy, M. (2013), 'Sustainability Land Use and the \environment', Routledge Publication, USA, p.155-165 States of America pp. 222-230.

Steedman, R. S. (2011), 'Geotechnics and Society', In Susumu, I, Geotechnics and Earthquake Geotechnics towards Global Sustainability, Springer Science and Business Media Publication, UK, p.75-88.

Steel Construction Institute, (2012), 'Integrated design for Successful Steel Construction', In Owens, G. W. and Davison, B, Steel Designers' Manual, John Wiley and Sons Publication, UK, p.10-33.

Steinmetz, G. (2006), 'Review Forum The politics of Method in the Human Sciences: Positivism and Its Epistemological others'. Canadian Journal of Sociology Online, pp. 632.

Stevels, A. and Griese, H. (2004), Electronics goes green: Current and future issues. In: H. Reichl, H. Griese & H. Pötter, ed. Electronics goes green: driving forces for future electronics. September 6-8, 2004 Berlin: IEEE, 45–54.

Storey, J. (2000), The Management of Innovation Problem; International Journal of Innovation Management, 4**,** 347-369.

Storey, J. et al. (2006), Supply chain management: theory, practice and future challenges, Journal of Operations and Production Management, Vo.26 No.7.

Straaten, J. V. and Spash, C. et al. (2012), 'Environmental Policy and Social Aims', Springer Science and Business Media Publication, USA, p.1-12.

Talbot, R. and Morgan, J. (2013), 'Sustainable Social Housing for No Extra Cost?', In Williams, K. and Burton, E. et al. Achieving Sustainable Urban Form, Routledge Publication, UK, p.319-335.

Tan, Y.-H. et al. (2011), Accelerating Global Supply Chains with IT-Innovations: ITAIDE Tools and Methods, Springer, UK.

Tashakkori, A., & Teddlie, C. (1998), Mixed methodology: Combining qualitative and quantitative approaches. Thousand Oaks, CA: Sage.

Taylor, C. (2000), 'The Kingfisher Science Encyclopedia', Kingfisher Publication, USA.

Taylor, P. et al. (2012), Toward a unified theory of project governance: economic, sociological and psychological supports for relational contracting Toward a unified theory of project governance: economic, sociological and psychological supports for relational contracting; Organization, (February 2012), pp.37 41.

Taylor, P., Carroll, T. N., and Burton, R. M. (2012), A contingency approach to designing project organizations: theory and tools A contingency approach to designing project organizations: theory and tools. Organization, (February), 37–41.

Teece, D. J. (2010), Business Models, Business Strategy and Innovation; Long Range Planning, 43**,** 172-194.

Teuteberg, F. and Wittstruck, D. (2010), A systematic review of sustainable supply chain management research; what is there and what is missing? Betriebliches Umwelt- und Nachhaltigkeits Management.

Thorpe, A. (2003), 'The role of data Transfer', In Brandon, P. and Betts, M. Integrated Construction Information, Routledge Publication, UK, p. 35-48.

Thorpe, M. (2010), 'Brickwork Level 3', Routledge Publishers, USA, p.1-45.

Tidd, J., Bessant, J. and Pavitt, K. (2005), Managing Innovation: Integrating Technological, Market and Organizational Change, Chichester, John Wiley & Sons.

Tiwari R., Herstatt C. (2011), Frugal Innovations for the "Unserved" Customer: An Assessment of India's Attractiveness as a Lead Market for Cost-effective Products // Working Paper No. 69, Institute for Technology and Innovation Management, Hamburg University of Technology.

Tladi, D. (2007), 'Sustainable Development in International Law: An analysis of key environ-economic instruments, Pretoria University Law Press, South Africa.

Trent, R. J. (2008), End-to-end lean management: a guide to complete supply chain improvement, J. Ross publishing, USA.

Trott, P. (2005), Innovation Management and New Product Development, Harlow, Prentice Hall.

Tsai, W., (2001), Knowledge transfer in Intra-organizational networks: Effects of network position and absorptive capacity on business unit innovation and performance; Academy of management journal, 44(5), pp.996–1004.

Tucker, R. B. (2001), Innovation: the new core competency. Strategy and Leadership, 29**,** 11-14.

Tusan, M. and Barczewski, S, et al. (2015), 'Britain since 1688: a Nation in the World', Routledge Publishers, USA, p.69-97.

Tyssen, C. and Cetinkaya et al. (2011), 'Sustainable Supply Chain Management: Practical Ideas for Moving towards Best Practice', Springer Science and Business Media Publication, UK, p.72-93.

Udeaja, C. and Perera, S. et al. (2013), 'Material Waste in the Construction Industry: A Review of the Legislative and Supply Chain Issues', In Richardson, A. Reuse of Materials and By products in Construction: waste Minimization Recycling', Springer Publishers, UK, p.5-28.

Ulrich, K.T. and Eppinger, S.D. (2011), Product Design and Development, 5th edition, McGraw-Hill, New York.

UN World Commission on Environment and Development (1987), Our Common Future Oxford University Press, UK

UNEP (United Nations Environment Programme), (2007), Buildings and Climate Change: Status, Challenges and Opportunities, lead authors P. Huovila, M. Ala-Juusela, L. Melchert, and S. Pouffary, UNEP Sustainable Buildings and Climate Initiative, Paris.

Uren, S. et al. (2000), 'Sustainable Construction in Practice', In Pauwels, S. and Boonstra et al. Sustainable Building (2000), Maastricht, the Netherlands Proceedings, Eneas, Technical Publishers, Netherlands, p.462-465.

UTTERBACK, J. M. (1986), Innovation and corporate strategy International Journal of Technology Management; 1(1–2), p119–132

Valen, S. M. and Moum, A. et al. (2014), 'Norway-Improved Governance and Innovation in Construction Projects', In Hampson, K. D. and Adriana, X. S. et al, R and D Investment and Impact in the Global Construction Industry, Routledge Publication, USA, p.222-245

Vastag, G. and Stentoft, J. et al. (2015), 'Research in the Decision Sciences for Global Supply Chain Network Innovations: Best Papers from the 2014 Annual Conference', (EDSI), FT Publication, USA

Veal, A. J. (2006), Research Methods for Leisure and Tourism: A Practical Guide. Harlow, England: Prentice Hall/Financial Times

Vickery, S. k. (2011), Integration in Global Supply Chains; In B.B. Flynn, et al., Managing Global Supply Chain Relationships: Operations, Strategies and Practices Business Science, USA

Vinodh, S., Sundararaj, G. and Devadasan, S.R. (2009), Total agile design system model via literature exploration; Industrial Management & Data Systems, 109(4), pp.570–588.

Vitullo, R. and Rumbarger, J. (2003), 'Architectural Graphic Standards for Residential Construction: The Architect's and Builder's Guide to Design, Planning, and Construction Details', John Wiley and Sons Publications, USA, p.80-91

Vlies RDVD, Maas GJ (2009), A social capital perspective to innovation management in construction; Paper presented at the 26th International Symposium on Automation and Robotics in Construction (ISARC 2009).

Volti, R. (2013), 'Society and Technological Change', Worth Publishers, USA, p 20-35.

Von Hippel E. (1988), The Sources of innovation. Oxford (UK): Oxford University Press.

Voss (2002), Case research in operations management, International Journal of operations & production management, Vol. 22, No. 2, pp195-219.

Vrijhoef, R. and Koskela, L. (1999), Roles of Supply Chain Management; Quality Assurance, 31(15), 133–146.

Warburton, J. and Evans, M. (2011), 'Geomorphology of Upland Peat: Erosion, Form and Landscape Change', Blackwell Publishing, UK

Wever, R., van Kuijk, J. and Boks, C. (2008), User-centred Design for Sustainable Behaviour. International Journal of Sustainable Engineering, 1(1) pp. 9-20.

Wheelwright, S. C. and Clark, K. B. (1992), Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality, New York, Free Press.

Whyte, A. (2014), 'Integrated Designs and Cost Management for Civil Engineers', CRC Publication, USA, p 110-142

Wiegman, L. and Blockstein, D. E. (2012), 'The Climate Solutions Consensus: What we Know and What to do about It', Island Publication, USA, p.90-119.

Wilkinson, S. J. (2015), 'Sustainable Construction Issues', In Christensen, P. H. and Wilkinson, S. J, Developing Property Sustainably, Routledge Publication, UK, p.147-167.

William, D. (2010), 'Life in the UK: The Land and the People', New Africa Press, UK, p.277-280.

Williamson, S. et al (2010), 'What is Management in Supply Chain Management? A Critical Review of Definitions, Frameworks and Terminology' Journal of Management Policy and Practices Vol.11 (4)

Winch GM (2010), Managing Construction Projects (2nd ed.): Wiley Black Well.

Wisner, J.D. et al (2009), Principles of Supply Chain Management: A Balanced Approach (2^{nd}) South-Western USA.

Wohler, T. (2002), Rapid Prototyping state of the industry: 2002 worldwide progress report, RPA of SME, Dearborn, MI, 2002.

Womack, D. J. J. et al (1990), The Machine that Changed the World, Rawlinson Associates, USA.

Woods, K. (2010), 'Human Rights and Environmental Sustainability', Edward Elgar Publishing, USA, p 1-26

Woolley, T. (2013), 'Low Impact Building: Housing using renewable Materials', John Wiley and Sons Publication, UK.

Wu, M. (2009), Modeling of Fragmentation in the Construction Industry, International Conference on Management and Service Science, pp.1–4.

Xue, X. et al. (2007), Coordination mechanisms for construction supply chain management in the Internet environment. International Journal of Project Management, 25(2), pp.150–157

Yang, G. (2011), 'Sustainability-Is it Worth it: Scientific Utilization of Energy and Sustainable Economy Development in China', In Parodi, O. and Banse, G. et al., Sustainable Development – the Cultural Perspective: Concepts – Aspects – Examples, Edition Sigma Publication, Germany, p.293-308.

Yao, H. J., Amydee, M., Fawcett, S. E. (2013), Awareness is not enough: Commitment and performance implications of supply chain integration; International Journal of Physical Distribution & Logistics Management, Vol. 43, Issue: 3, pp.205-230.

Yeung, A. K., Ulrich, D. O., Nason, S. W. and von Glinow, M. A. (1999), Organizational learning capability, New York: Oxford University Press.

Yuva, J. (2002), Knowledge management – the supply chain nerve centre, Inside Supply Management, Institute for Supply Management, July, pp. 34-43.

Zhang, P. (2012), Attitude toward knowledge sharing in construction teams; Industrial Management and Data Systems, 112(9), pp.1326–1347

Zuru, Z. and Mingqiang, Z. (2011), 'Green Supply Chain Management in Construction Industry', In Dai, M. Innovative computing and Information: International Conference ICCIC 2011, Springer Science and Business Media Publication, (Part 2), UK, p.81-86.

Bibliography

A commitment to people - our Biggest Asset; A report from the Movement for Innovation's working group on Respect for People, November 2000

Achieving Sustainability in Construction Procurement, Sustainability Action Group of the Government Construction Clients' Panel (GCCP), June 2000

Adetunji, I.O. (2005), Sustainable Construction: A Web-Based Performance Assessment Tool; Loughborough University.

Aiyewalehinmi, E. (2013), Factor Analysis of Job Motivation in the Construction Industry; researchinventy.com, 3(7), pp.34–42

Alashwal, A. M., Rahman, H. A., & Beksin, A. M. (2011), Knowledge sharing in a fragmented construction industry: On the hindsight. Construction, 6(7), 1530–1536.

Allu, E. L. A. Ebohon, O. J. and Taki, A. H. (2013) Architectural Design: It's Roles on Buildings for Sustainable Development. International Postgraduate Research Conference IPGRC, 8TH – 10TH April, Salford-UK, pp. 92-104

Ampofo-Anti, N. (2009), Environmental impacts of construction materials use: a life cycle perspective. Green building handbook South Africa, Volume 1: (A guide to ecological design), pp 1-9.

Anumba, C., Egbu, C. & Carrillo, P. (2008), Knowledge management in construction 1st ed., Oxford: Blackwell Publishing Ltd.

Arif, M. Rahimian, F.P. and Goulding, J.S. (2012), Promoting Offsite Construction: Future Challenges and Opportunities. Journal of Architectural Engineering (ASCE), 18(2), pp.75-78

Armstrong, C.M. (2011), Implementing education for sustainable development: the potential use of time-honoured pedagogical practice from the progressive era of education. Journal of Sustainability Education, 2, 2151-7452.

Baldauf C, M. and Hubbard, M. (2011), Key issues for the global economy and construction in 2011, Davis Langdon.

Basu, R., and Wright, J.N., (2010), Total Supply Chain Management 1st ed., Oxford: Elsevier.

Baumgartner, R.J. (2011), Critical perspectives of sustainable development research and practice. Journal of Cleaner Production, 19, 783-786.

Bennett, J and Crudgington, A. (2003), Sustainable development: Recent thinking and practice in the UK. Proceedings of the Institution of Civil Engineers Engineering Sustainability, 156, Issue ES, 27-32.

BIS, (2011), Infrastructure supply chains: barriers and opportunities, London.

BIS, (2013a), An economic analysis of the sector.

BIS, (2013b), Small Business Survey 2012: SME Employers: A report by BMG Research.

BIS, (2013c), Supply Chain Analysis into the Construction Industry A Report for the Construction Industrial Strategy.

BIS, (2013d), UK Construction: An economic analysis of the sector. London.

BIS, (2014), Small Business Barometer: A report by BMG Research.

Boyle, C. (2004), Considerations on educating engineers in sustainability. International Journal of Sustainability in Higher Education, 5(2), 147-155.

BQF, (2013), How to achieve and sustain outstanding levels of performance; Managing Processes with Agility, 5(February), pp.32–34

Bratic, D. (2011), Achieving a Competitive Advantage by SCM; IBIMA Business Review

Braungart, M. and McDonough, W. (2009), Cradle to cradle: Remaking the way we make things; New York: North Point Press.

Bredillet, C.N. (2013), Agile Project Management: Essentials from the Project Management Journal, John Wiley and Sons.

Brennan, M. and Cotgrave, A.J. (2014), Sustainable development: a qualitative inquiry into the current state of the UK construction industry; Structural Survey, 32(4), 315-330.

Building a better quality of life, (2000), A strategy for more sustainable construction, DETR

Bunz, K.R., Henze, G.P. and Tiller, D.K. (2006), Survey of sustainable building design practices in North America, Europe and Asia. Journal of Architectural Engineering, 12, 33-62.

Carter, C.R. and Rogers, D.S. (2008), A framework of sustainable supply chain management: moving toward new theory; International Journal of Physical Distribution & Logistics Management, 38(5), pp.360–387.

Ceric, A. (2012), Communication risk in construction Projects: Application of principal-agent theory. Organization, Technology and Management in Construction: An International Journal, 4(2), pp.522–533.

Chartered Institute of Building-CIB, (1999), Agenda 21 on Sustainable Construction; CIB Report Publication 237, July 1999, Rotterdam

Chen, I. J., and Paulraj, A. (2004), Towards a theory of supply chain management: the constructs and measurements; Journal of Operations Management, 22(2), 119–150.

Childerhouse, P. et al. (2003), Re-engineering a construction supply chain: a material flow control approach. Supply Chain Management: An International Journal, 8(4), pp.395–406.

CIRIA, (2013), Implementing Lean in construction: Overview of CIRIA's guides and a brief introduction to Lean, London.

Coley, F.J.S. and Lemon, M. (2009), Exploring the Design and Perceived Benefit of

Sustainable Solutions: A Review. Journal of Engineering Design, 20 (6), PP. 543-554.

Conboy, K. and Fitzgerald, B. (2004), Toward a Conceptual Framework of Agile Methods: A Study of Agility in Different Disciplines., pp.37–44.

Construction (Design and Management) Regulations (1994): www.hmso.gov.uk/si/si1994/Uksi_19943140_en_1.htm

Court, P. et al. (2012), Design of a lean and agile construction system for a large and complex mechanical and electrical project; Building, pp.1–14

Dave, B. & Koskela, L. (2009), Collaborative knowledge management—A construction case study; Automation in Construction, 18(7), pp 894–902

Du Plessis, C. (2002), Agenda 21 for Sustainable Construction in Developing Countries: A Discussion Document, Report for CIB and UNEP–IETC.

Ebohon, O. J. (2011), Sustainable Agenda 21: Its Significance and Relevance to the Environment. Proceedings of the Architects Registration Council of Nigeria, (ARCON) 4TH Architects' Colloquium. Theme: Architecture and the Nigerian Development Agenda IV. 28th -30th June, 2011. Abuja. 1-13

Ekundayo, D., Zhou, L., Udeaja, C., Pearson, J. and Perera, S. (2011), Mapping of sustainability education to construction related curricula: A case Study of quantity surveying (QS) degree programme, University of Salford, 698-707.

Fergusson, H. and Langford D.A. (2006), Strategies for managing environmental issues in construction organizations; Engineering, Construction and Architectural Management, 13(2) 171-185

Garland, N., Hadfield, M., Howarth, G. and Middleton, D. (2009), Investment in sustainable development: A UK perspective on the business and academic challenges. Sustainability, 1, 1144-1160.

Gorgolewski, M. (2008), Designing with reused building components: some challenges. Building Research and Information, 36(2), 175-188.

Gunasekaran, A., and Ngai, E. (2005), Build-to-order supply chain management: a literature review and framework for development: Journal of Operations Management, 23(5), pp.423–451.

Halliday, S. (2008), Sustainable Construction; Oxford: Butterworth Heinemann.

Hartshorn, J., Maher, M., Crooks, J., Stahl, R. and Bond, Z. (2005), Creative destruction: Building toward sustainability; Canadian Journal of Civil Engineering, 32, 170-180.

HM Government, (2008), Strategy for sustainable construction, London

Hopwood, B., Mellor, M. and O'Brien, G. (2005), Sustainable Development: Mapping Different Approaches. Sustainable Development, 13, 38-52.

Janssen, G. and Hendriks, C. (2002), Sustainable use of recycled materials in building construction; Advances in Building Technology, 1, 1399-1406.

Kibert, C. J. (2013), Sustainable construction: green building design and delivery; 3rd ed. New Jersey: Wiley.

Langston C.A. and Ding G.K.C (2001), Sustainable practices in the built environment; Oxford: Butterworth Heinemann.

London, K., & Kenley, R. (2001), An industrial organization economic supply chain approach for the construction industry: a review. Construction Management and Economics, 19(8), 777–788.

Love, P.E.D., Irani, Z. and Edwards, D.J. (2004), A seamless supply chain management model for construction; Supply Chain Management: An International Journal, 9(1), pp.43–56

Manrodt, K.B. and Vitasek, K. (2005), Lean practices in the supply chain: Benchmarking your lean journey, Chicago.

Medineckiene, M., Turskis, Z. and Zavadskas, E.K. (2010), Sustainable construction taking into account the building impact on the environment; Journal of Environmental Engineering and Landscape Management, 18(2), 118-127.

Meehan, J. and Bryde D.J. (2013), Procuring sustainably in social housing: The role of social capital; IPSERA, Nantes, 296-310.

Opoku, A. and Fortune, C. (2011), Leadership in construction organizations and the promotion of sustainable practices; In: Wamelink, J. W.F., Volkers, L. and Geraedts, R.P. (eds.) Proceedings of CIB international Conference of W055, W065, W089, W112, TG76, TG78, TG81,Management and Innovation for a Sustainable Built Environment, Amsterdam, The Netherlands.

Pappas, E. (2012), A New Systems Approach to Sustainability: University Responsibility for Teaching Sustainability in Contexts; Journal of Sustainability Education; Planning:

Delivering a Fundamental Change, Department of Transport, Local Government and the Regions, December 2001.

Preuss, L. (2001), In dirty chains? Purchasing and greener manufacturing; Journal of Business Ethics, 34(3), 345-359

Reputation, Risk & Reward (2002), The business case for sustainability in the UK property sector: The Report of the Sustainable Construction Task Group.

Fairclough, Sir John (2002), Rethinking Construction, Innovation and Research, A Review of Government R and D Policies and Practices

Rethinking Construction (1998), The Report of the Construction Task Force

Santor, J. R. A. (1999), Cronbach's Alpha: A Tool for Assessing the Reliability of Scales.

Journal of Extension, 37 (2)

Saunders, M. Lewis, P. and Thornhill, A. (2009), Research methods for business students, 5th edition, London, FT Prentice Hall

Sev, A. (2009), How Can the Construction Industry Contribute to Sustainable Development? A Conceptual Framework, Sustainable Development, 17 (3), pp. 161-

173.

Smyth, B. and Schroder, J. (2004) Sustainable Building Guide.

www.ccc.gov.nz/sustainablebuildinguide

Tam, V. (2011), Rate of reusable and recyclable waste in construction; The Open Waste Management Journal, 4, 28-32

Tan, Y., Shen, L. and Yao, H. (2011), Sustainable construction practice and contractors' competitiveness: A preliminary study. Habitat International, 35, 225-230.

Tashakkori, A. and Teddlie, C. (1998), Mixed Methodology - Combining Qualitative and

Quantitative Approaches, London, Sage Publications.

Wang, L. G. William, J. and Jones, P. (2009), Case Study of Zero Energy House Design in UK; Energy and Buildings, 41 (11), pp. 1215-1222.

Zhang, L. and Fan, W. (2013), Improving performance of construction projects: A project manager's emotional intelligence approach; Engineering, Construction and Architectural Management, 20(2), 195-207.